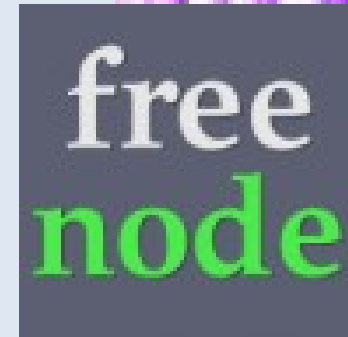
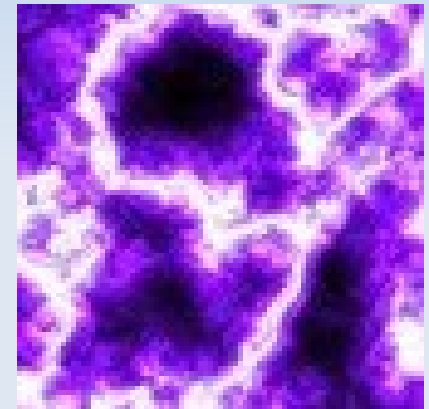


# Introduction

References and Presentation at:  
<http://www.elinux.org/ALS-i2c>

# Introduction

- Dave Anders aka prpplague



# Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI



# Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
- Partners in TinCanTools



# Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
- Partners in TinCanTools
- Board Bring: You, Me, and I2C

# Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
- Partners in TinCanTools
- Board Bring: You, Me, and I2C
  - Communication Principles

# Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
- Partners in TinCanTools
- Board Bring: You, Me, and I2C
  - Communication Principles
  - Drivers and Software Tools

# Introduction

- Dave Anders aka prpplague
- Currently Contracted with TI
- Partners in TinCanTools
- Board Bring: You, Me, and I2C
  - Communication Principles
  - Drivers and Software Tools
  - Board Bringup Use Cases

# Communication Principles

- Asynchronous Communication

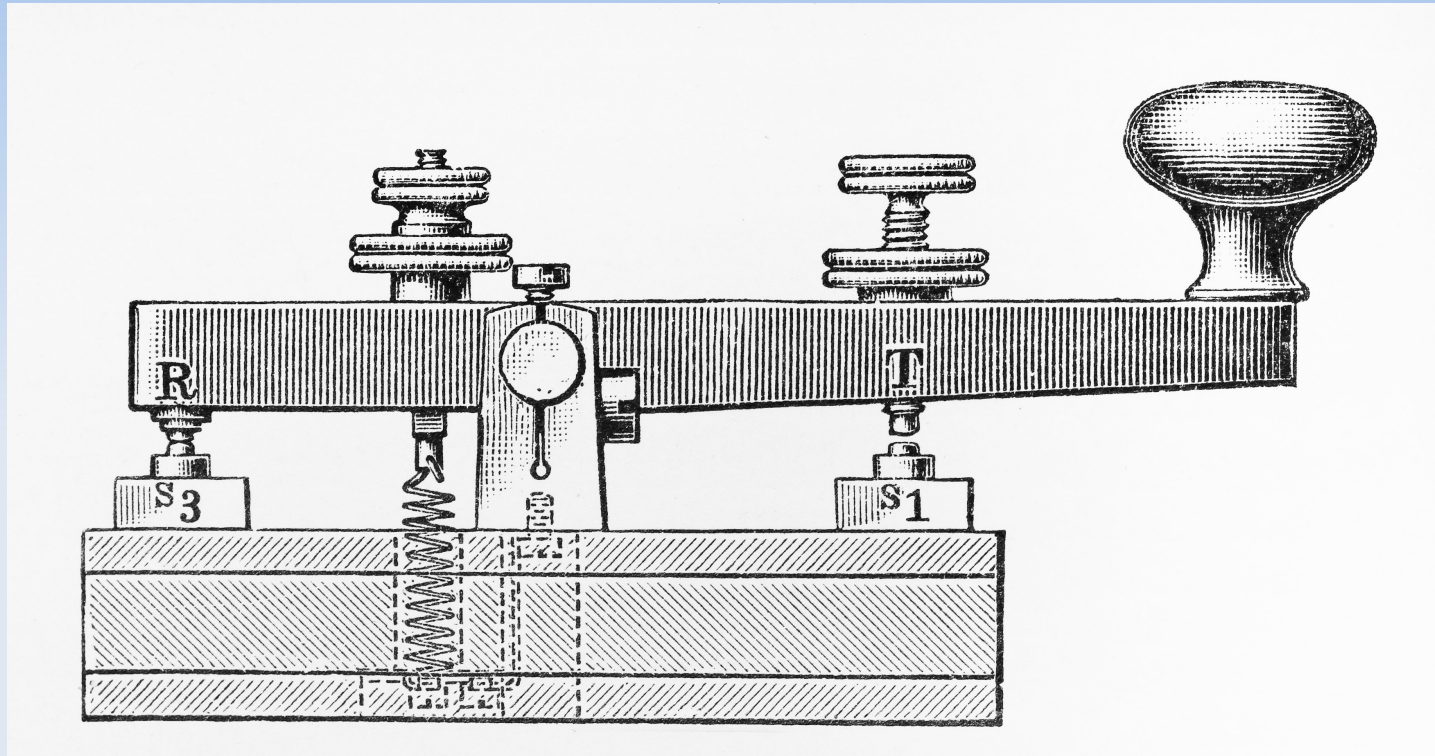
# Communication Principles

- Asynchronous Communication
  - No External Clock Signal

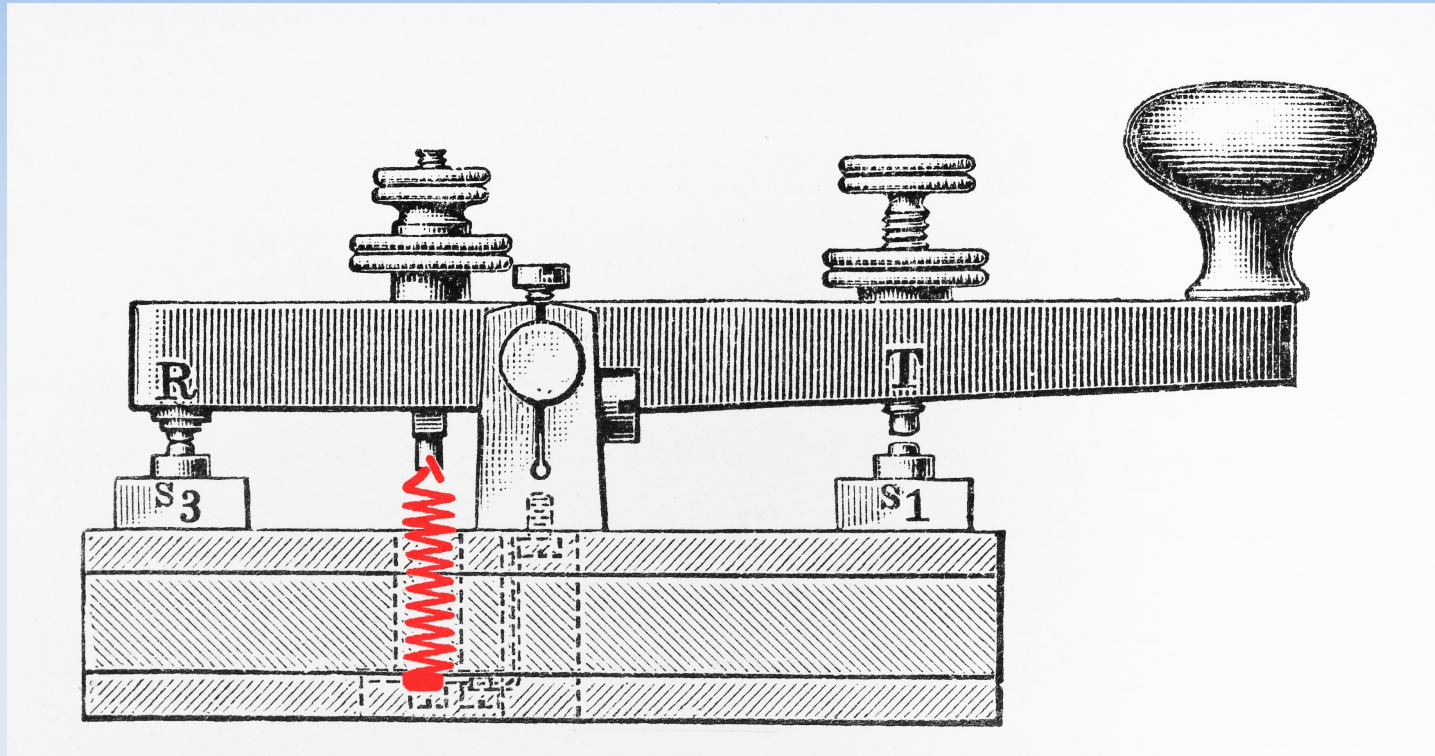
# Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph

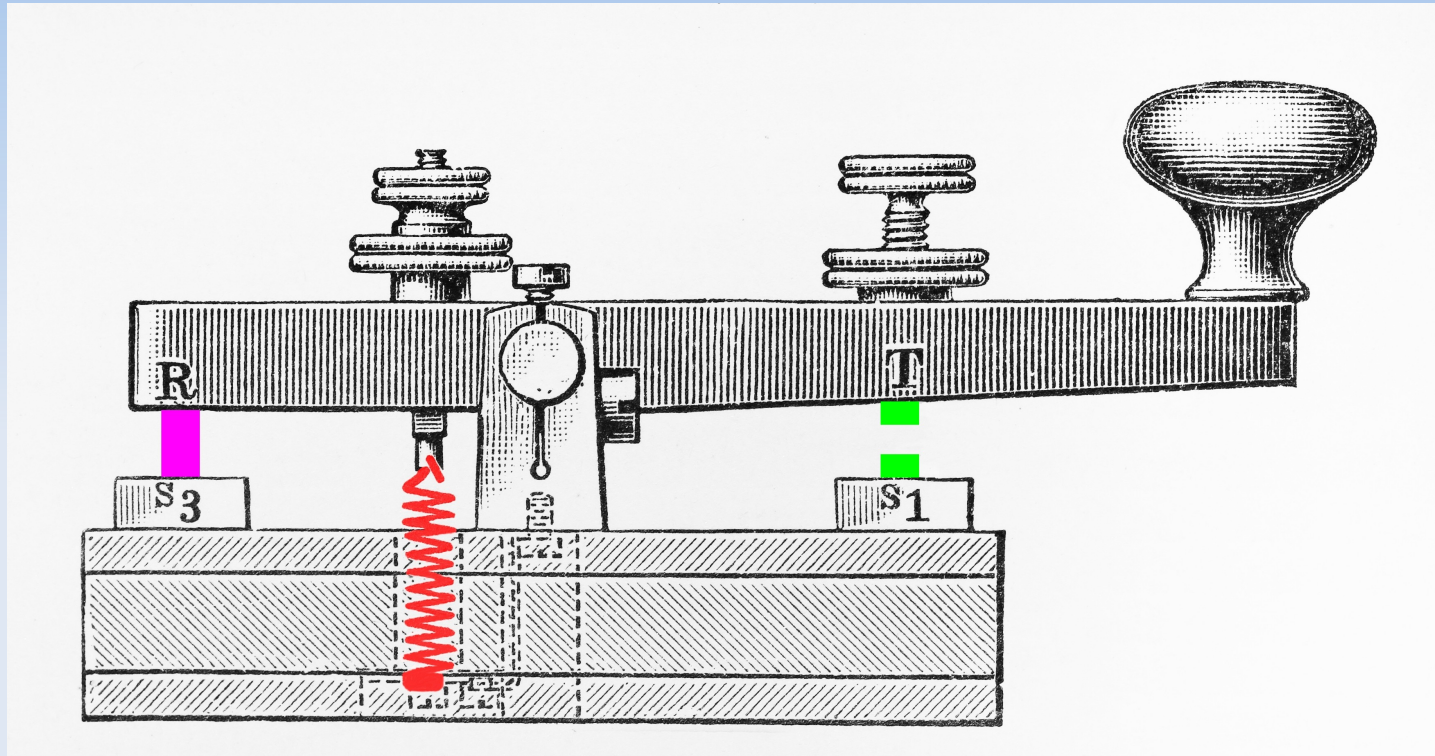
# Communication Principles



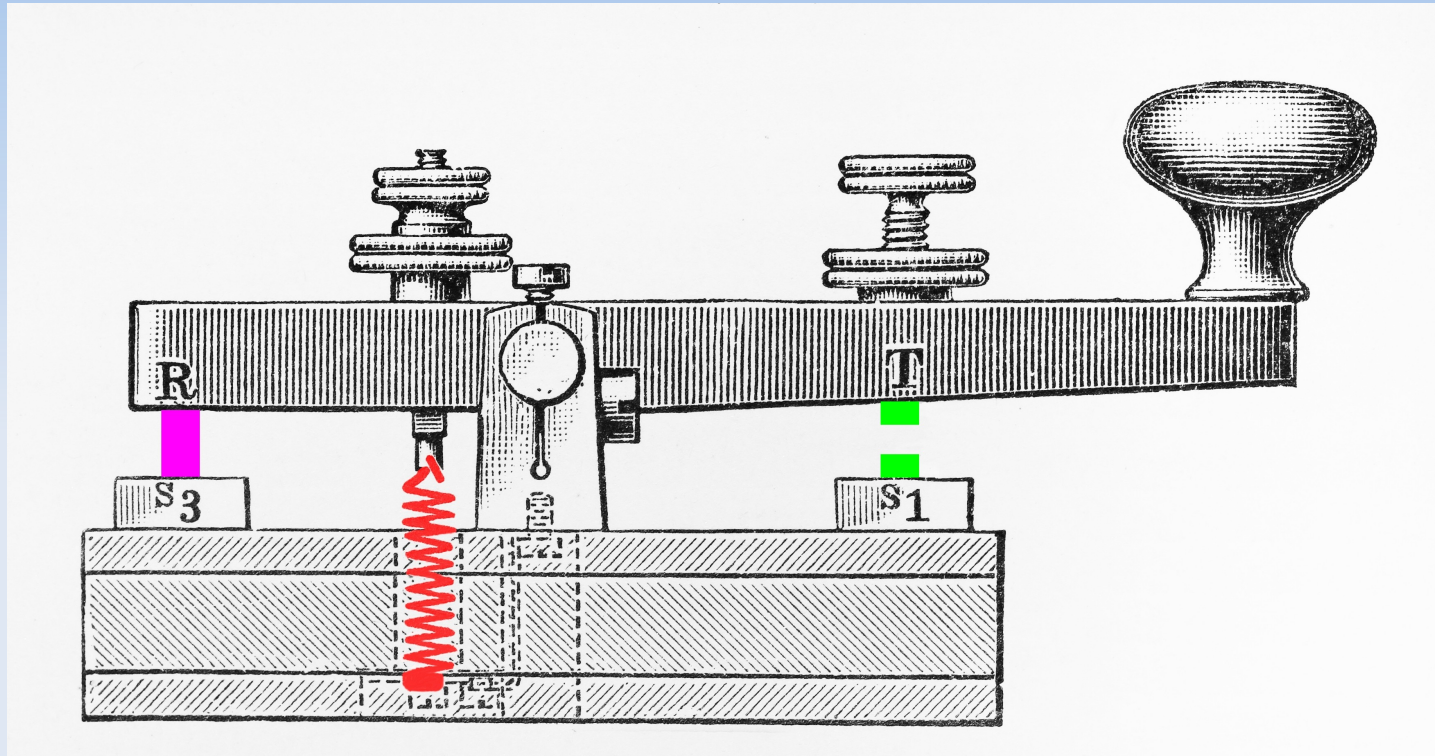
# Communication Principles



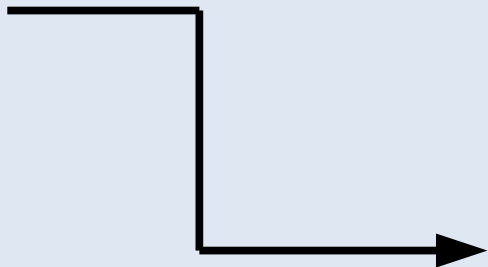
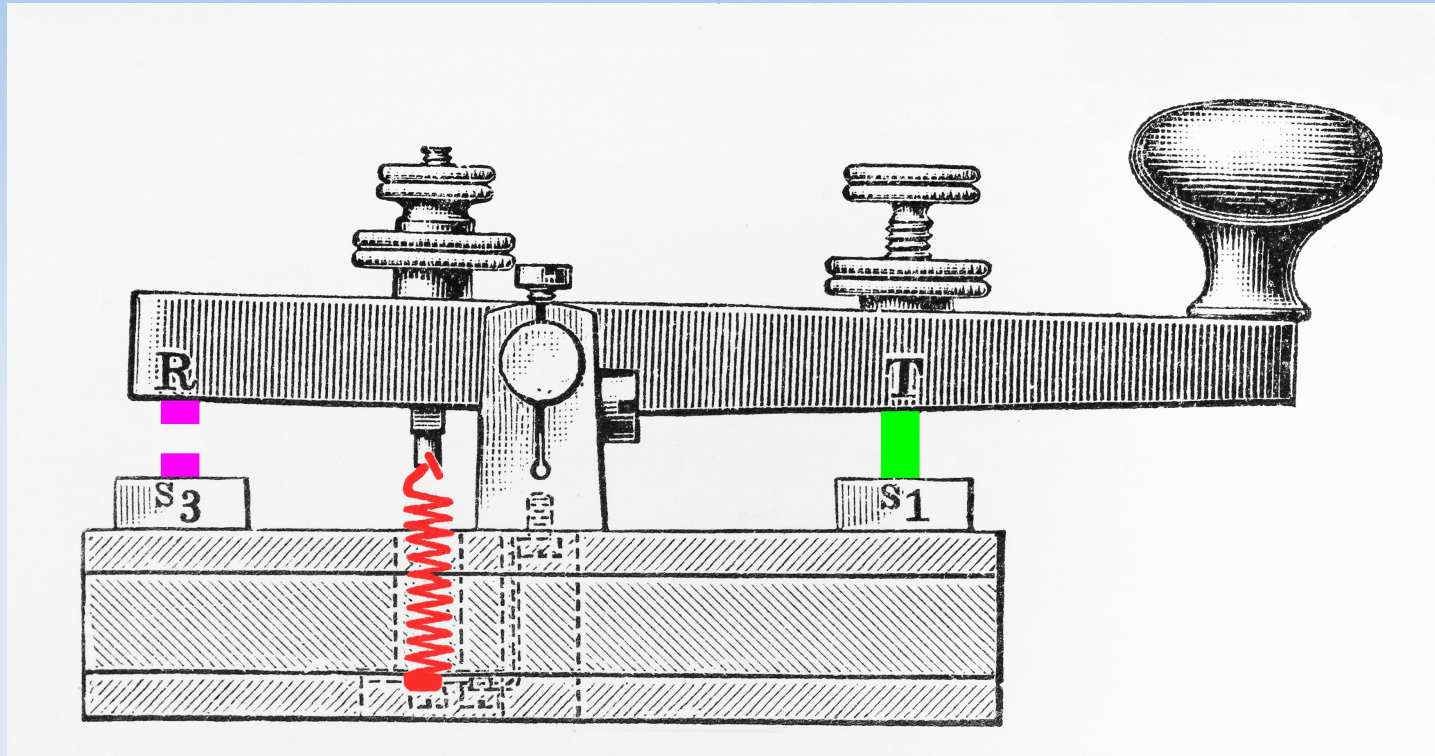
# Communication Principles



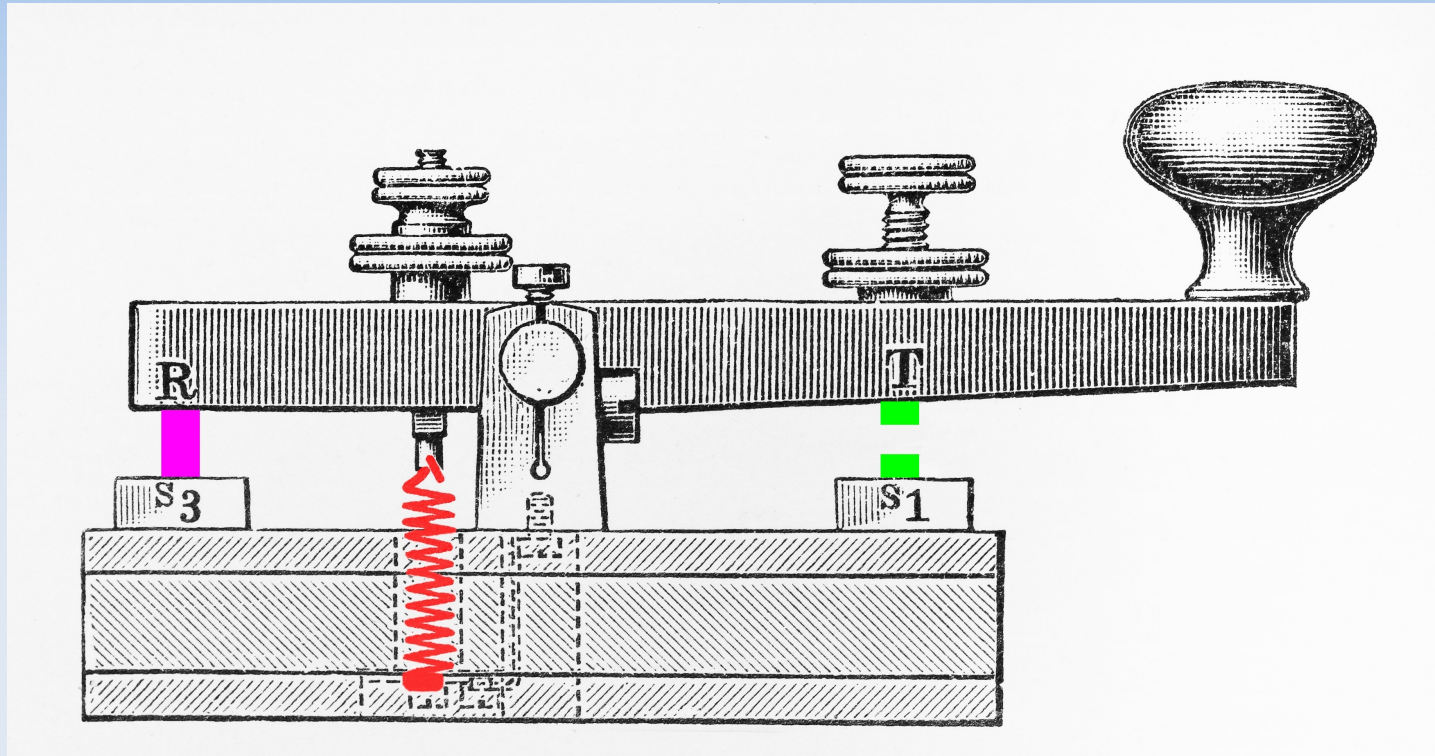
# Communication Principles



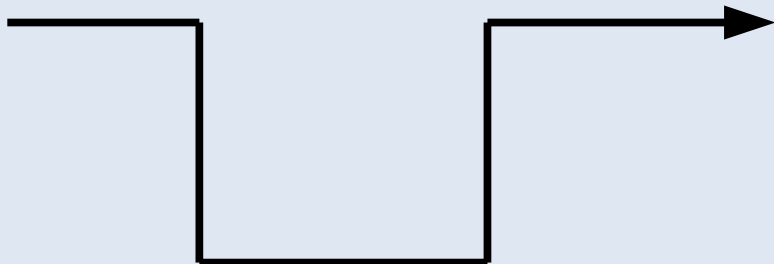
# Communication Principles



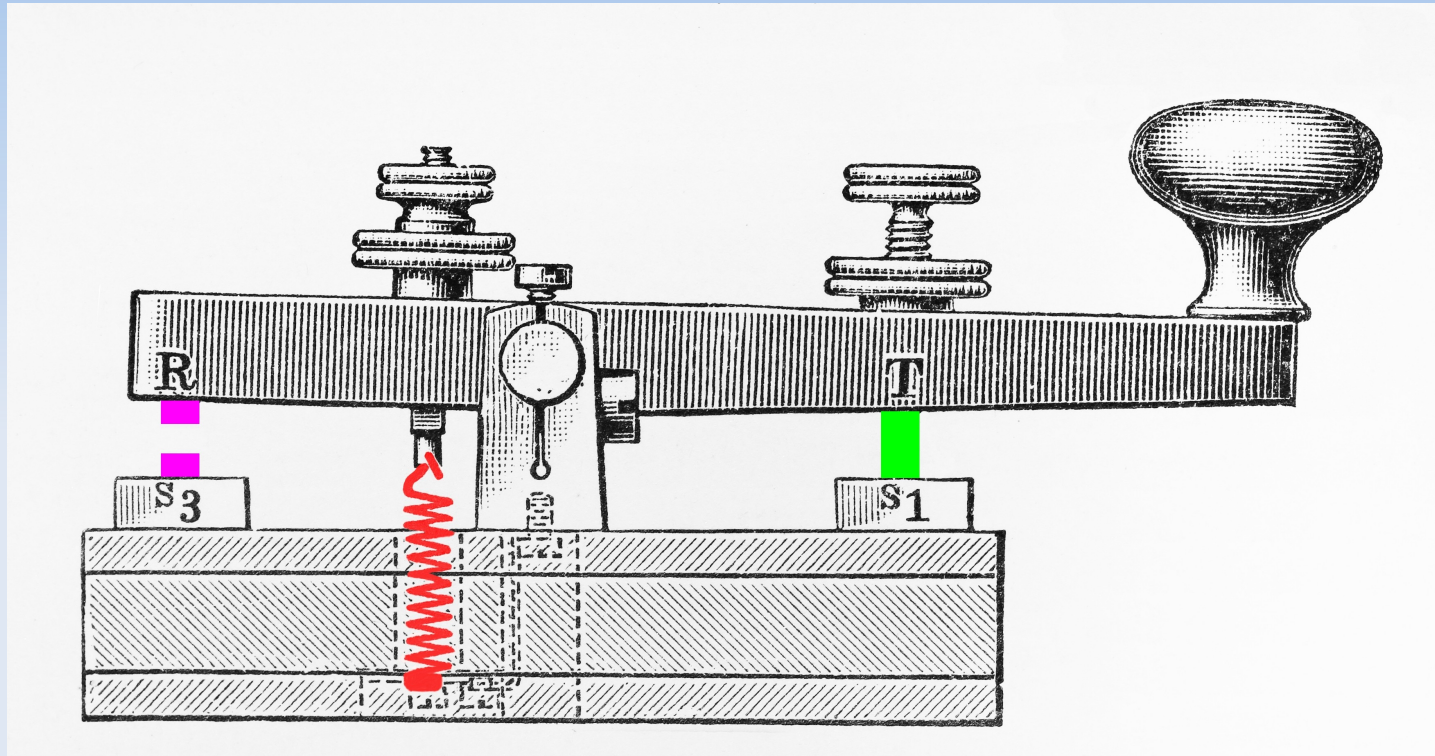
# Communication Principles



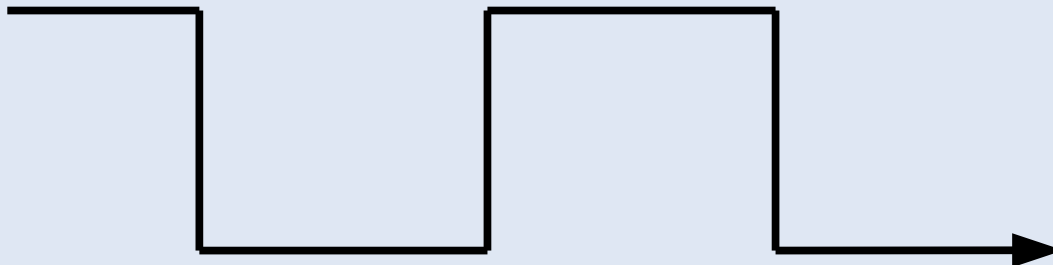
DOT



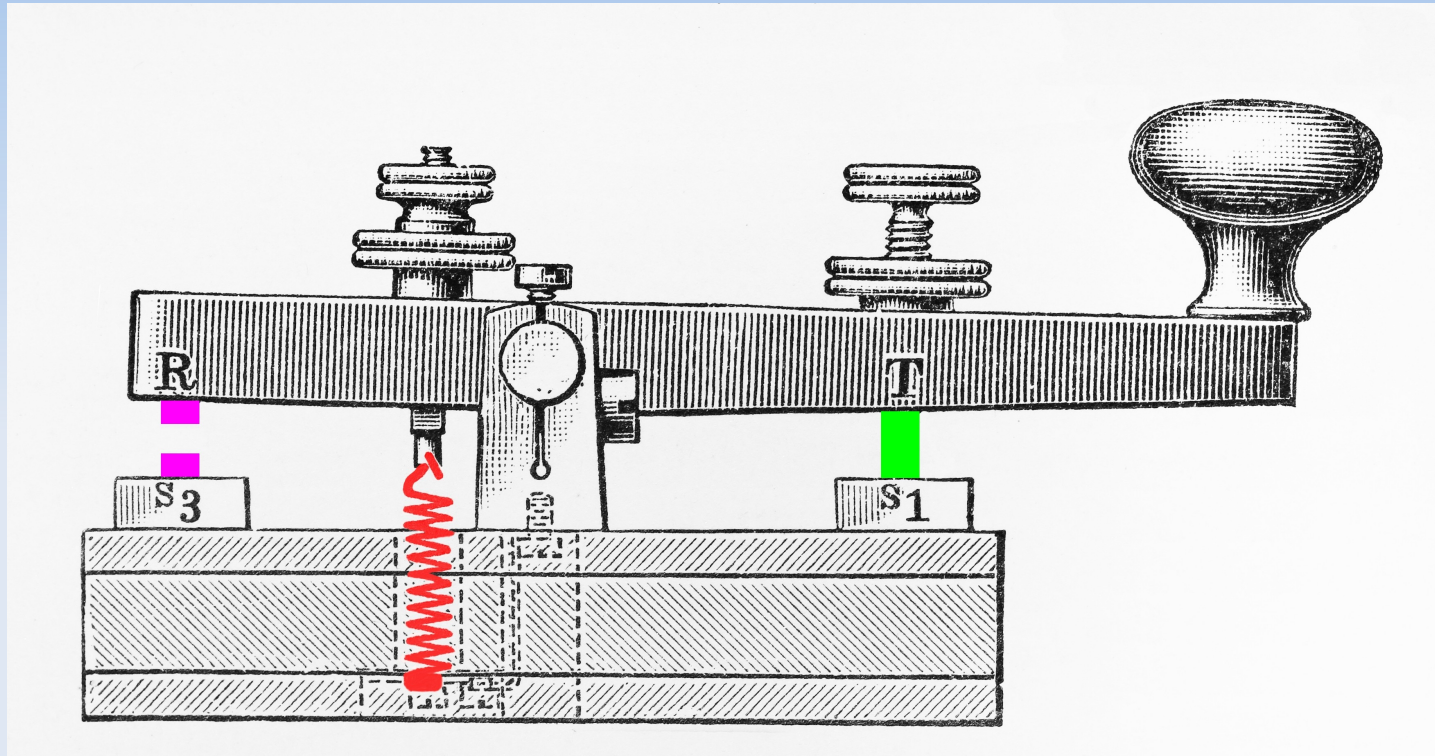
# Communication Principles



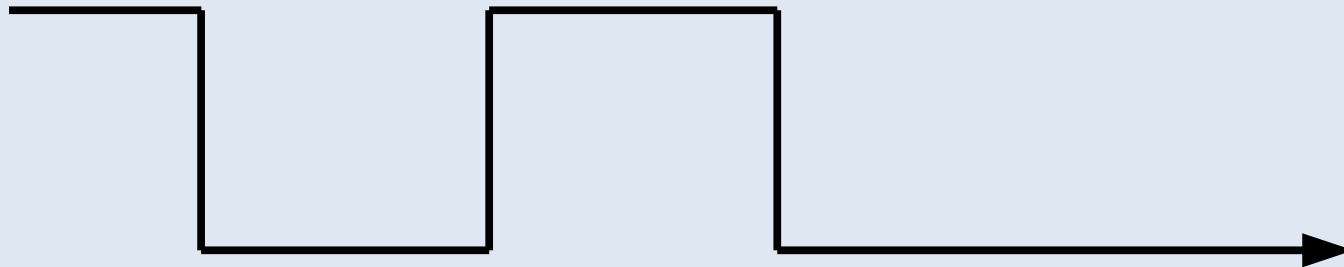
DOT



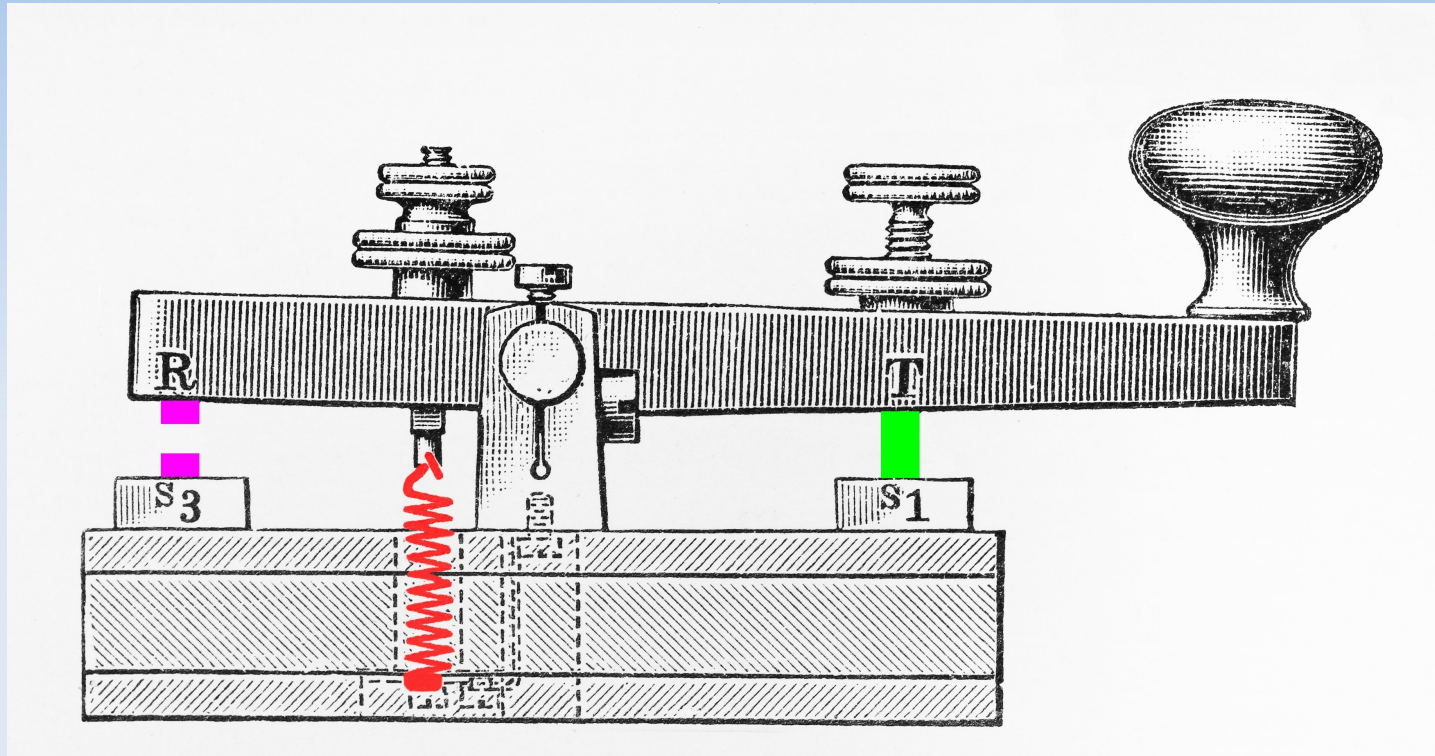
# Communication Principles



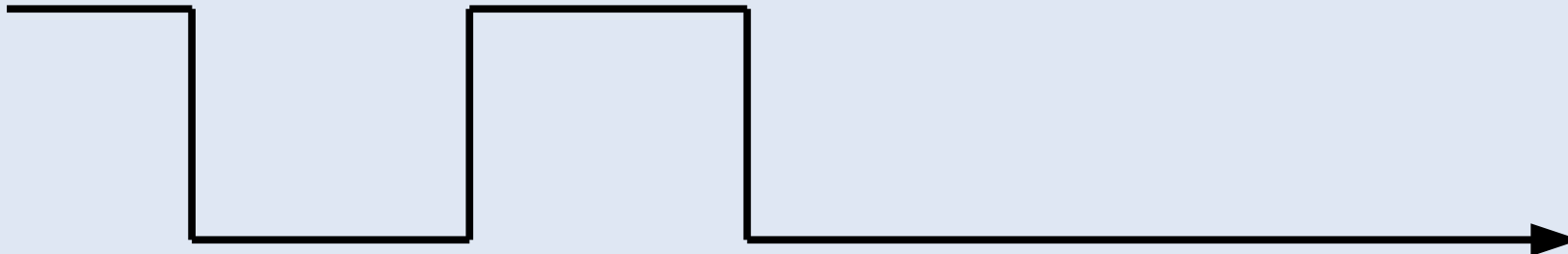
DOT



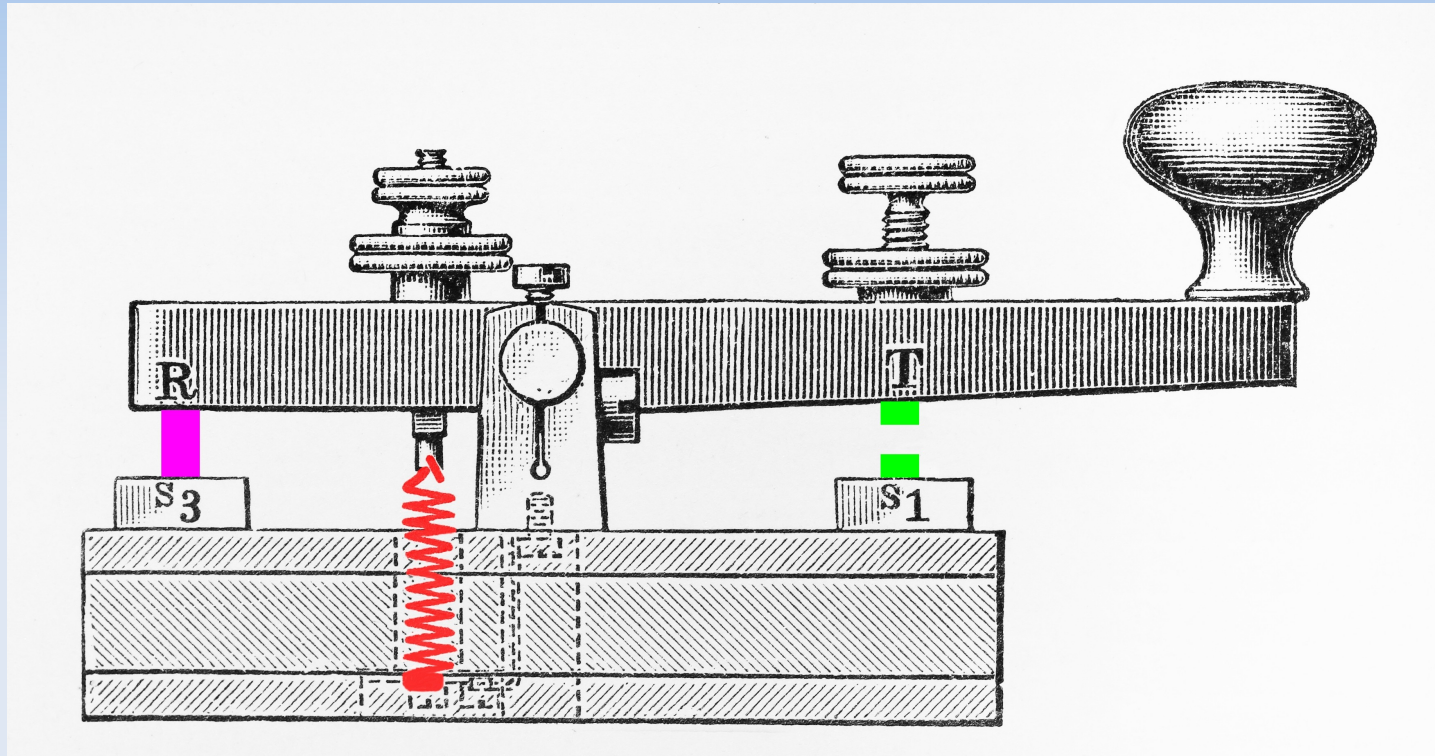
# Communication Principles



DOT

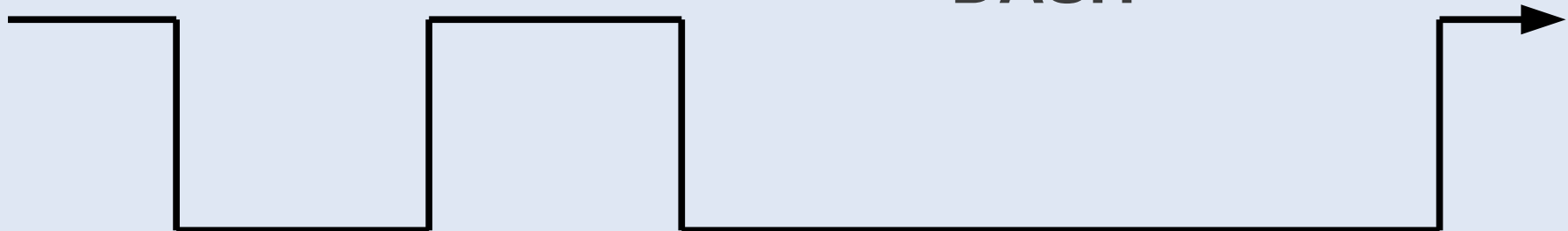


# Communication Principles

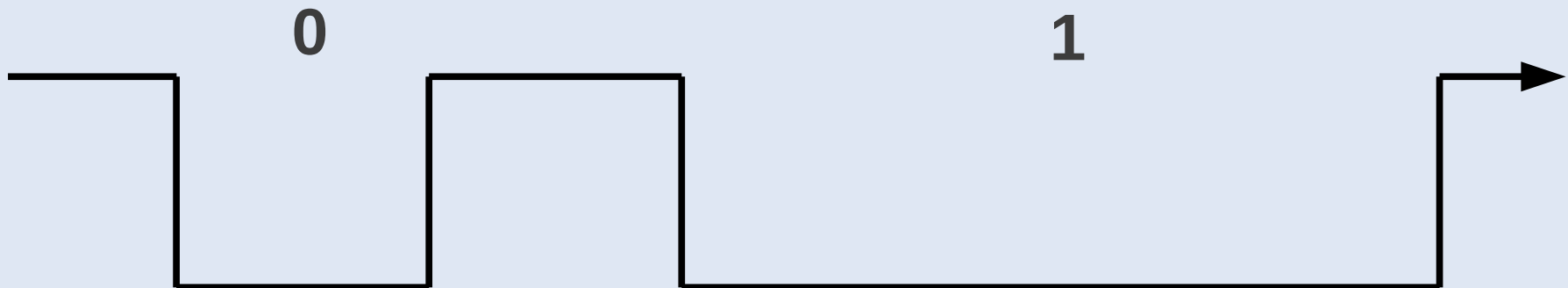
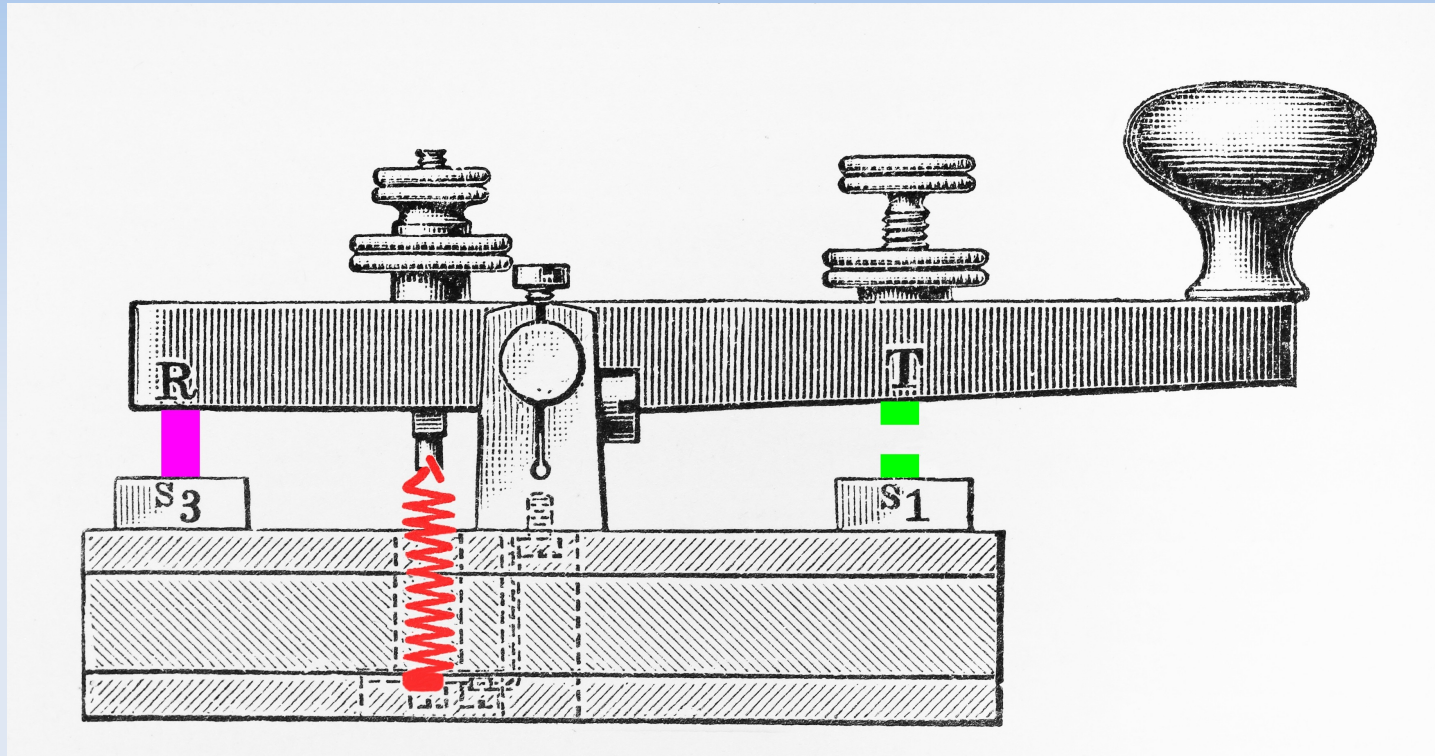


DOT

DASH



# Communication Principles



# Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART

# Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
    - Universal
    - Asynchronous
    - Receiver
    - Transmitter

# Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
  - Agreed Upon Period Length
    - DOT / DASH
    - Baud Rate

# Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
  - Agreed Upon Period Length
  - Accurate Timing Device

# Communication Principles

- Asynchronous Communication
  - No External Clock Signal
  - Morse Code / Telegraph
  - RS-232/UART
  - Agreed Upon Period Length
  - Accurate Timing Device
    - Crystals
    - Oscillators
    - System Clock Dividers
      - Atmel AVR with 10MHz clock
      - $10\text{MHz} / 20 / 4 = 125000$
      - $115200 \text{ vs. } 125000 = 8.5\% \text{ error}$

# Communication Principles

- Asynchronous Communication
- The Problem



# Communication Principles

- Asynchronous Communication
- The Problem
  - Simple peripherals
  - Reduced external components
  - No need to set period length
  - Wide range of frequencies



# Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication

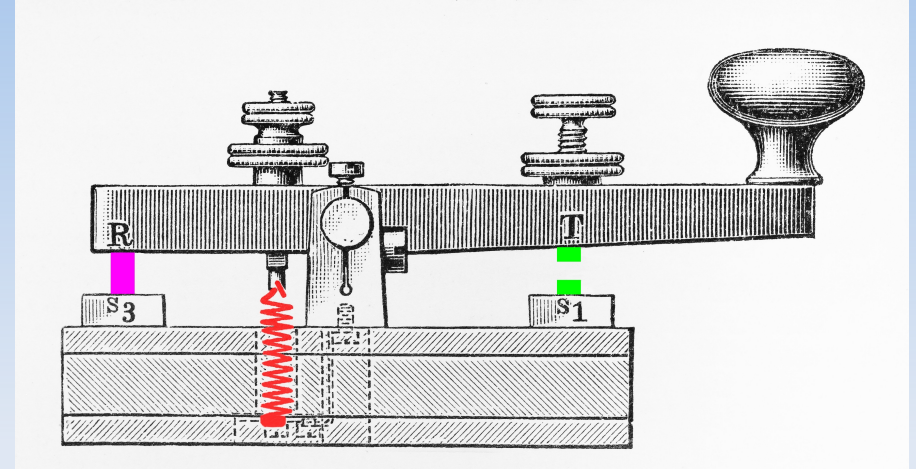
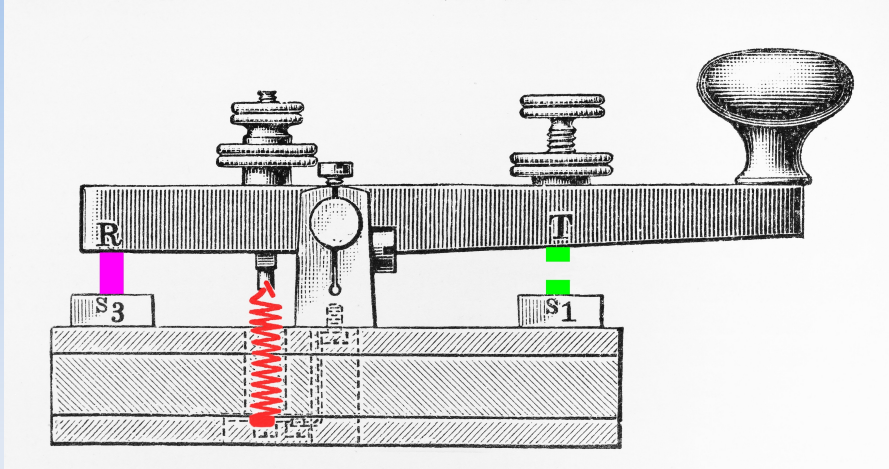
# Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal

# Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal
  - Edison Stock Quotes

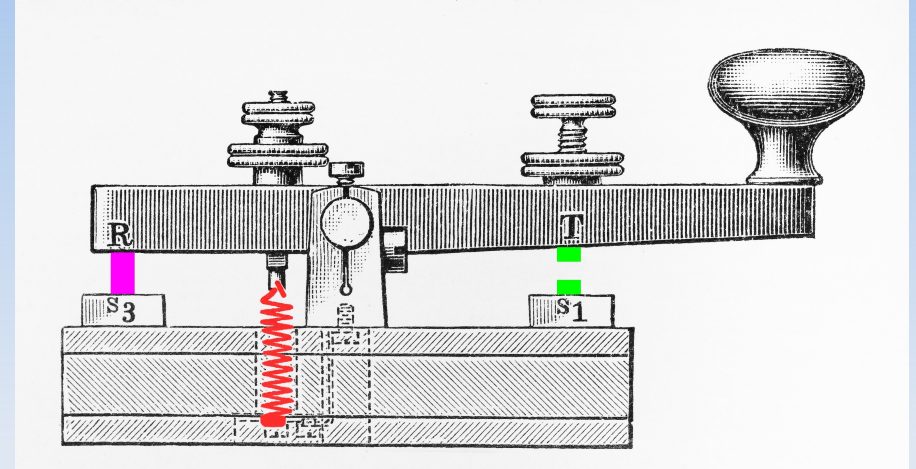
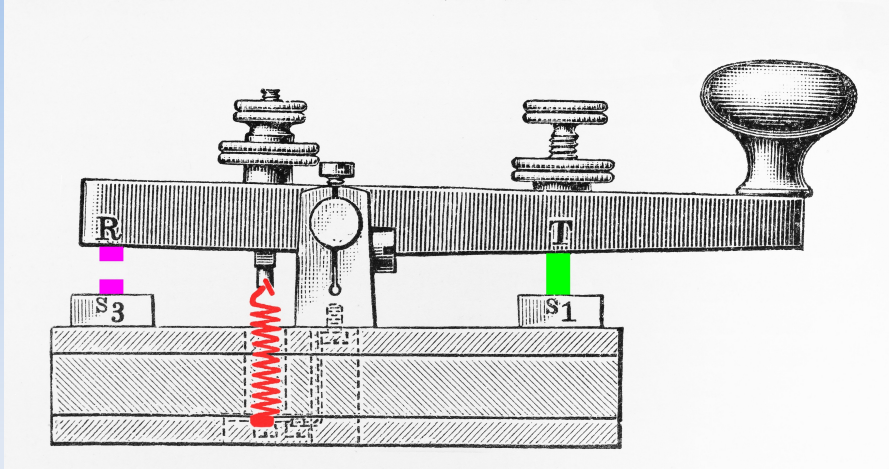
# Communication Principles



→  
CLOCK

→  
DATA

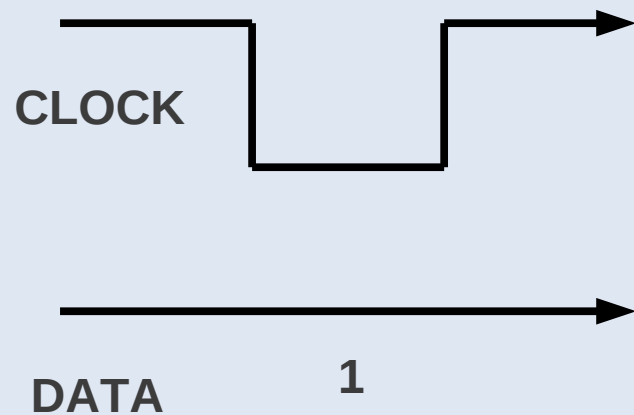
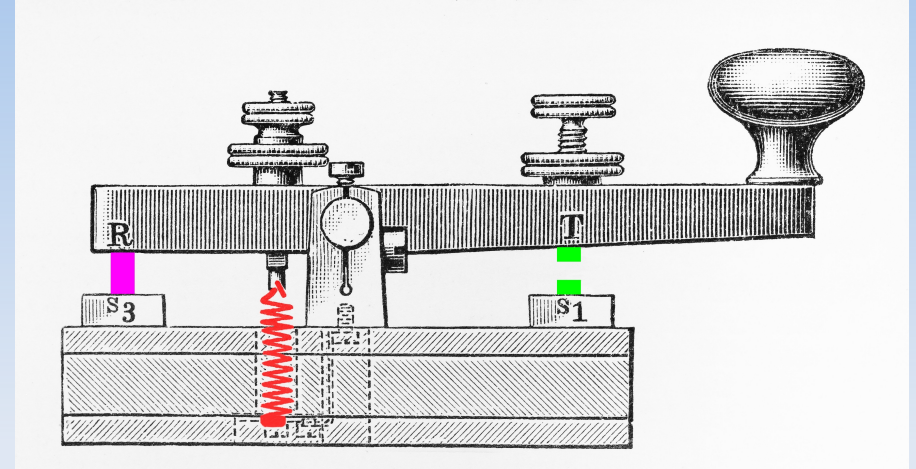
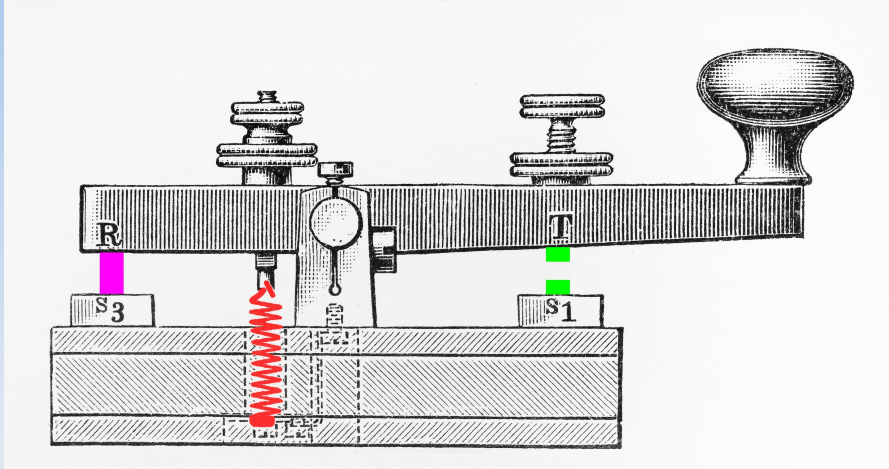
# Communication Principles



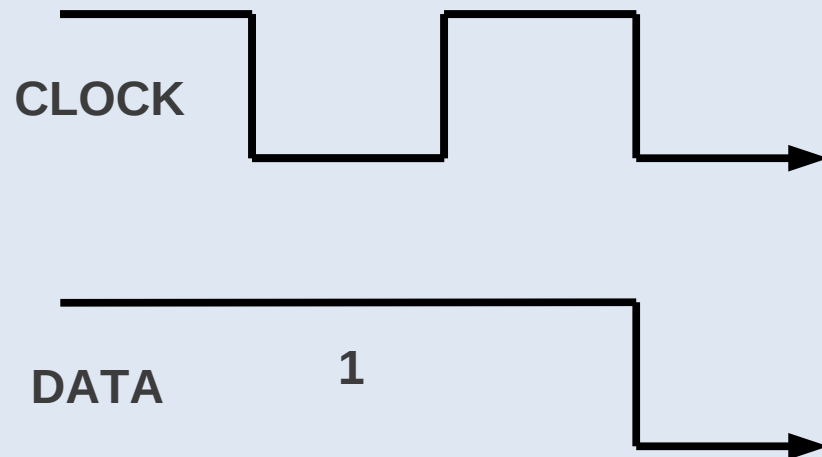
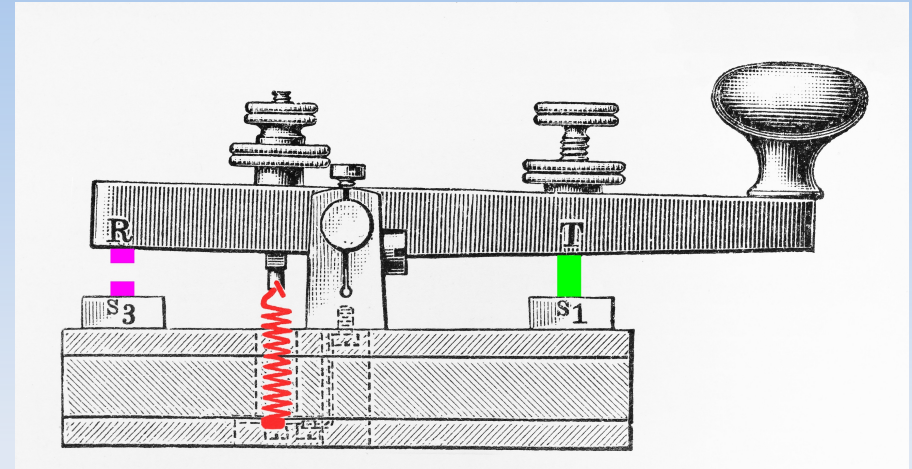
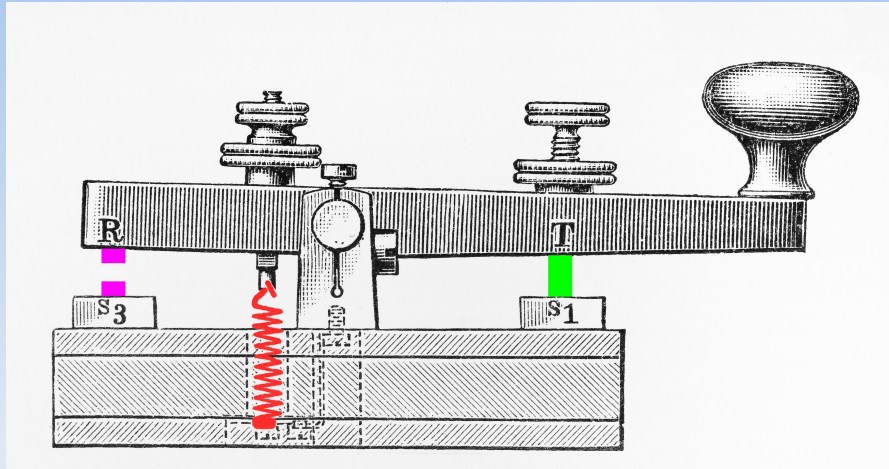
CLOCK

DATA

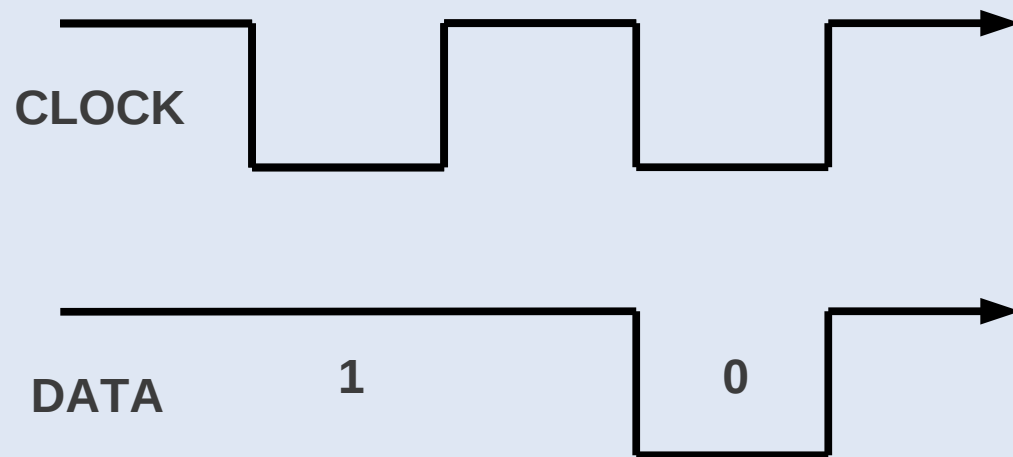
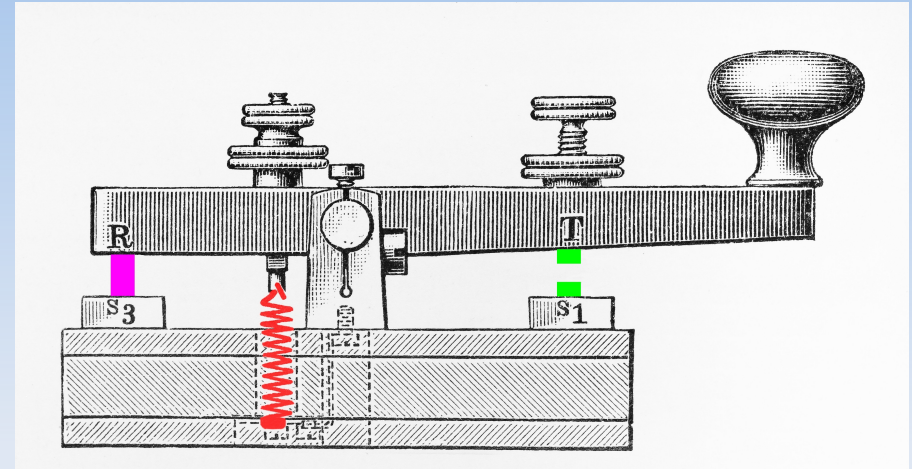
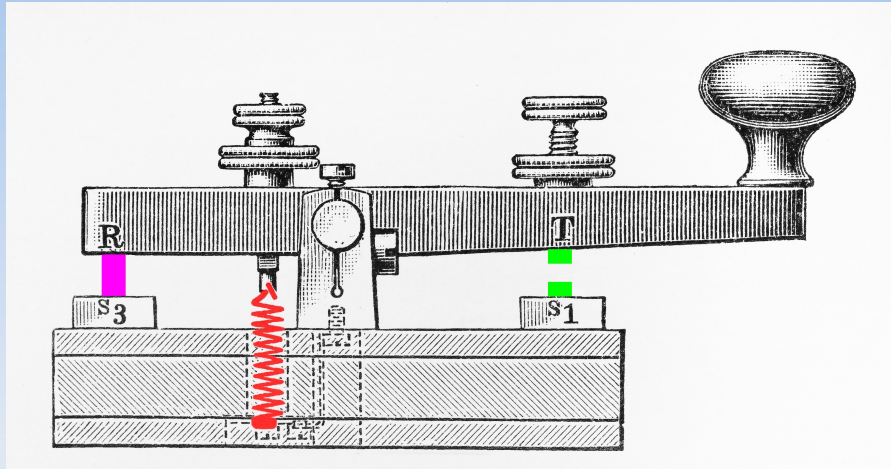
# Communication Principles



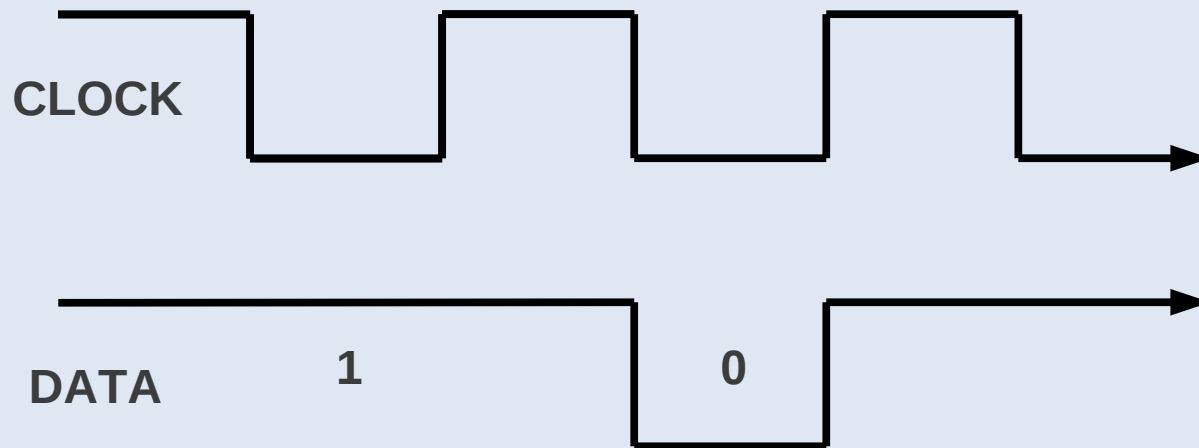
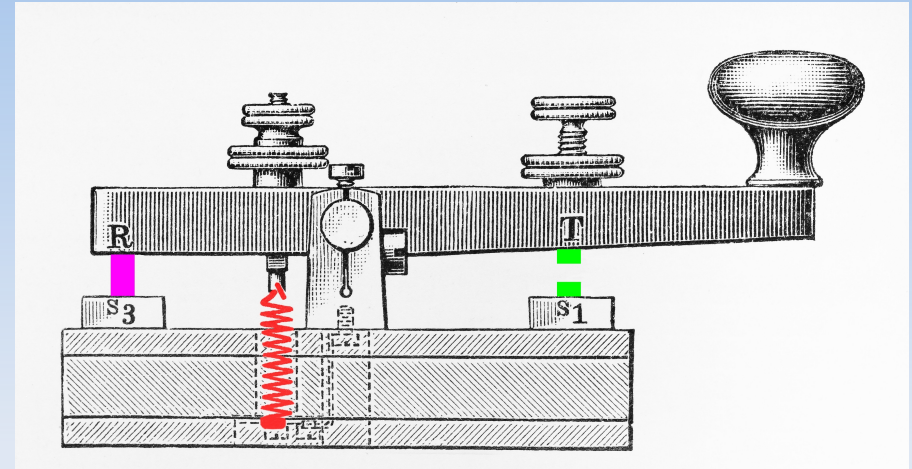
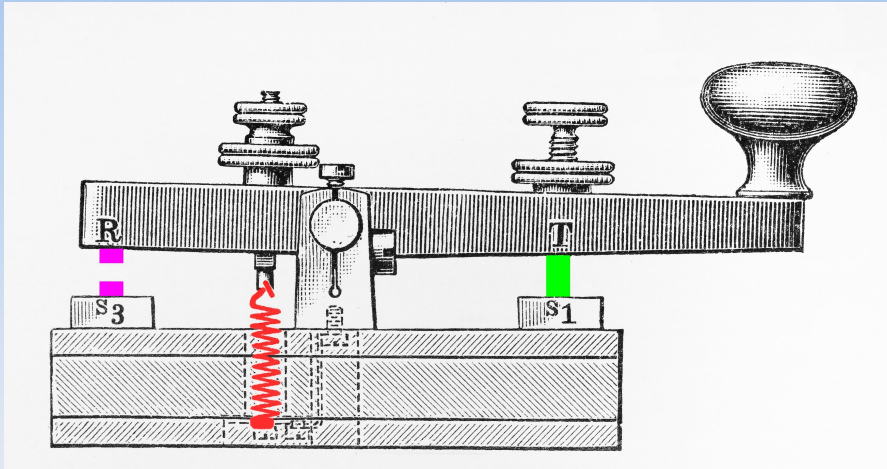
# Communication Principles



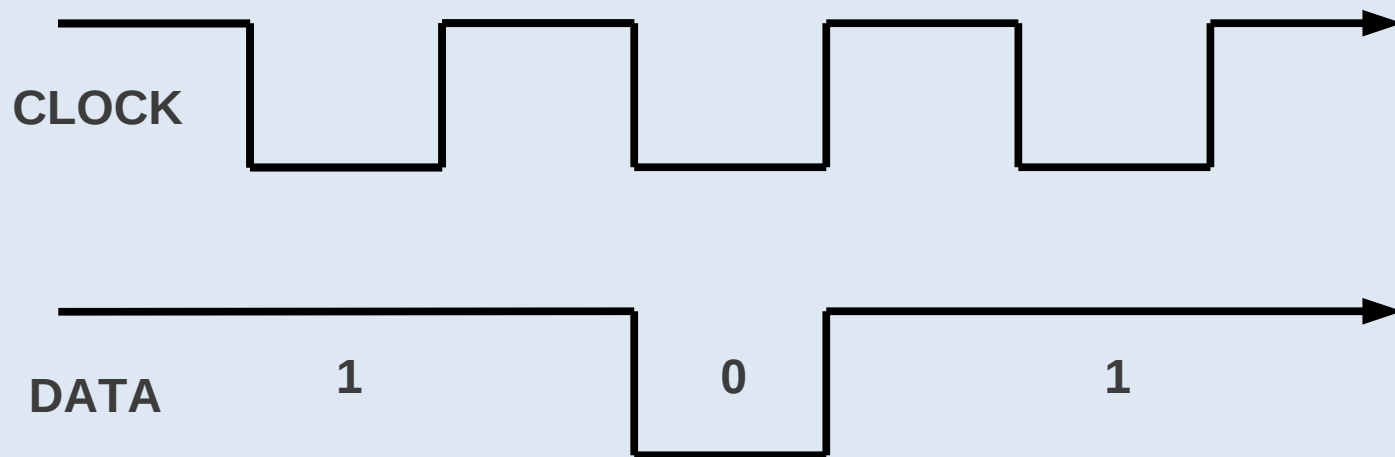
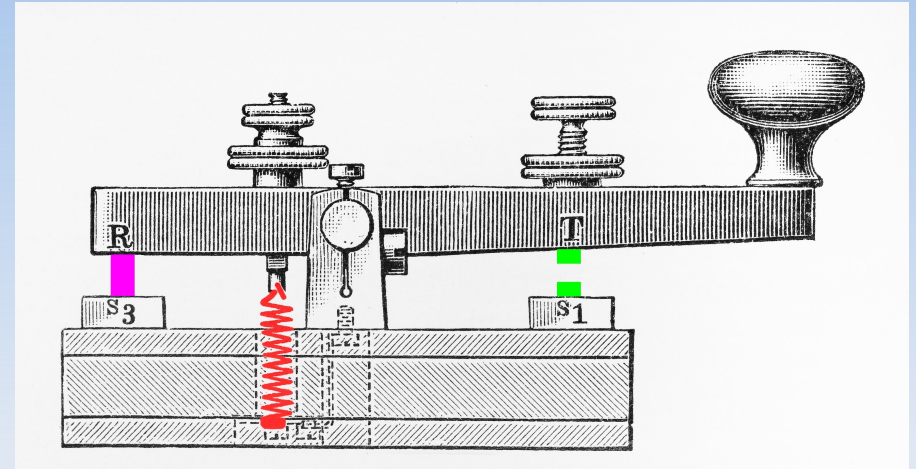
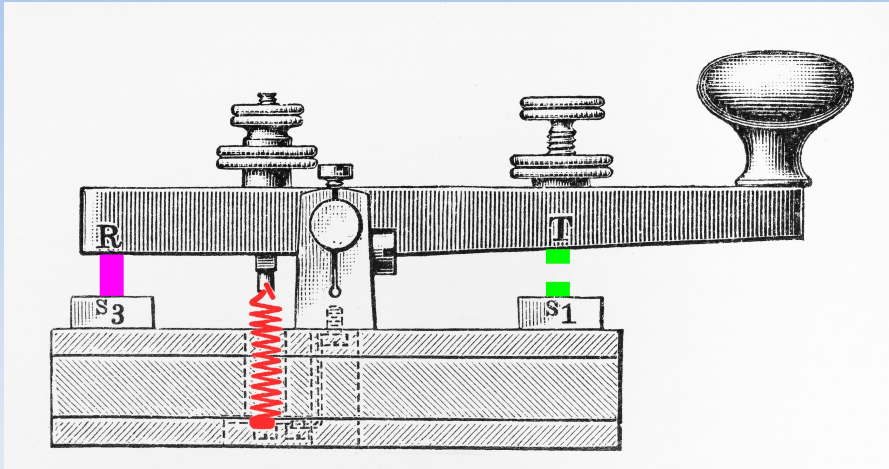
# Communication Principles



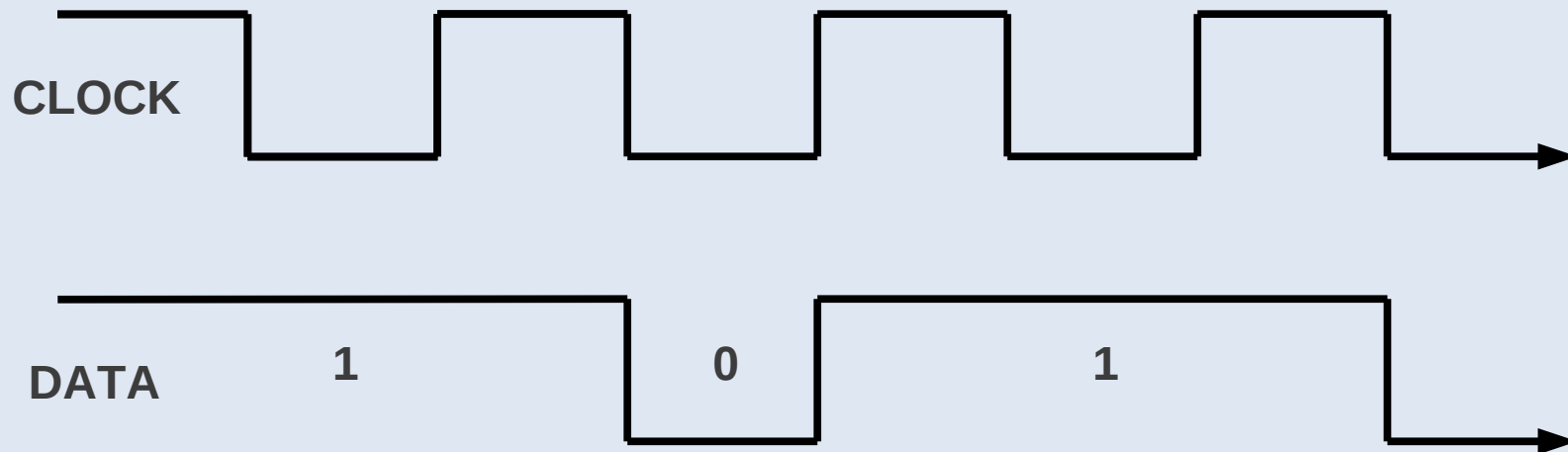
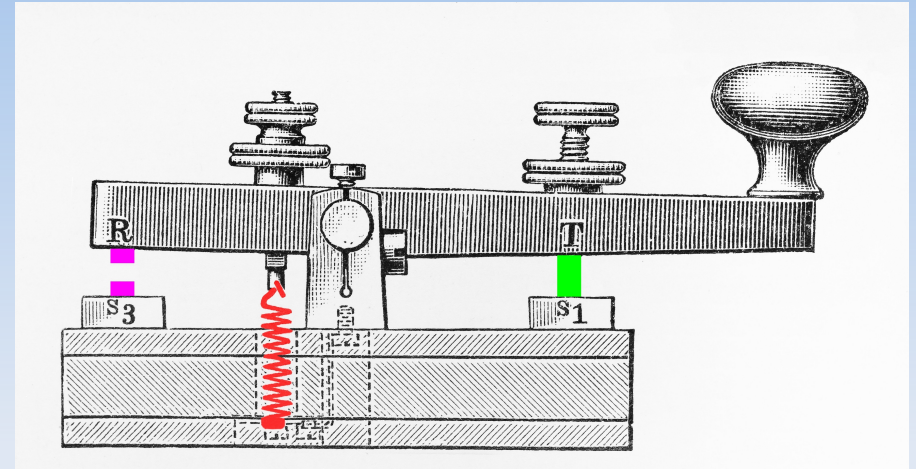
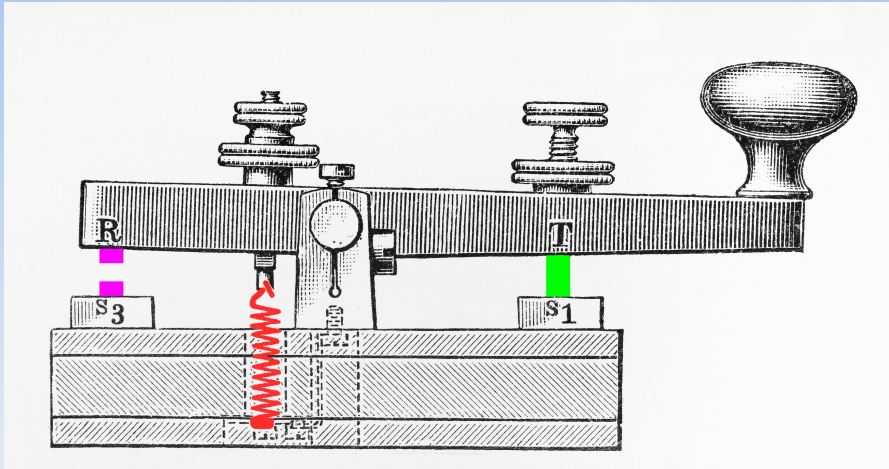
# Communication Principles



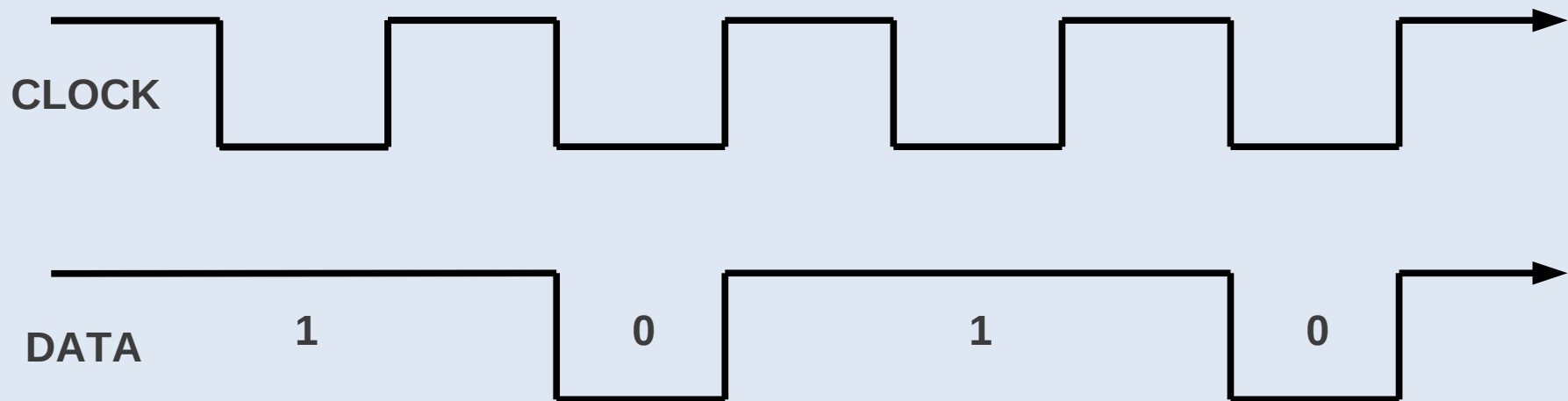
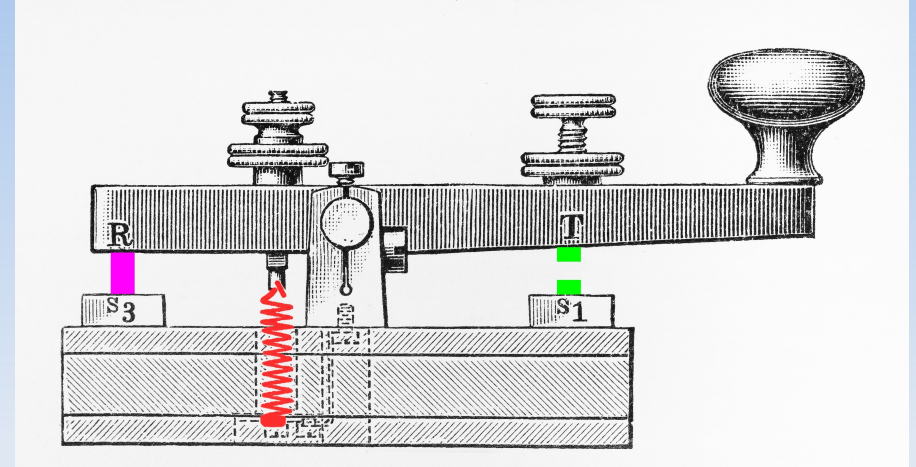
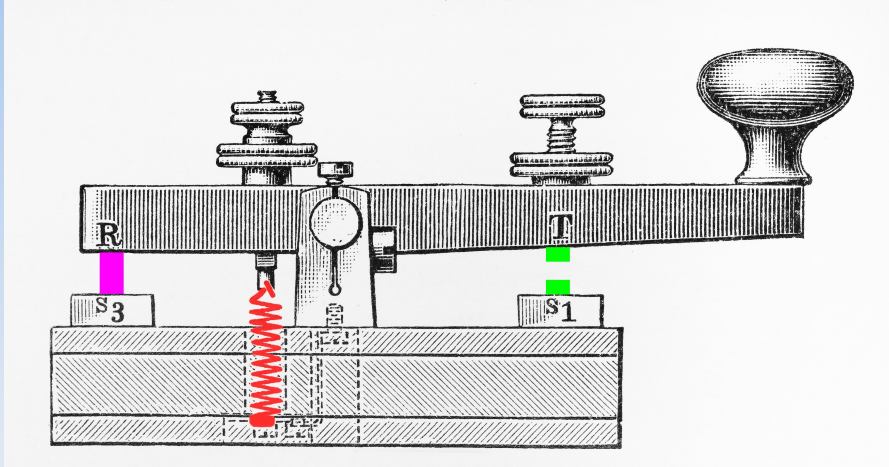
# Communication Principles



# Communication Principles



# Communication Principles



# Communication Principles

- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal
  - Edison Stock Quotes
  - NXP Developed I2C

# Communication Principles

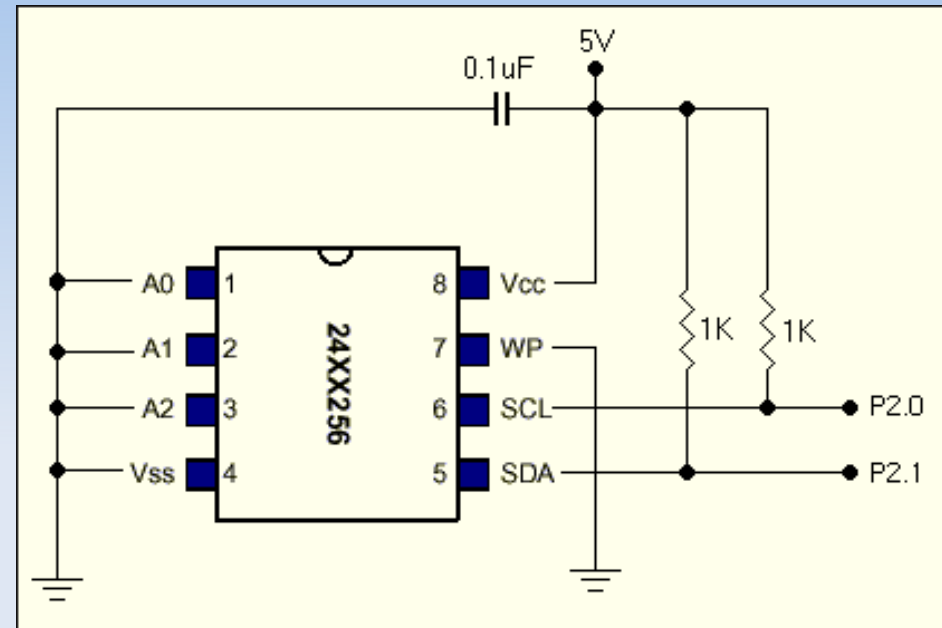
- Asynchronous Communication
- The Problem
- Synchronous Communication
  - Uses Dedicated Clock Signal
  - Edison Stock Quotes
  - NXP Developed I2C
  - Intel Refined with SMBus

# Interfacing

- Physical Connections

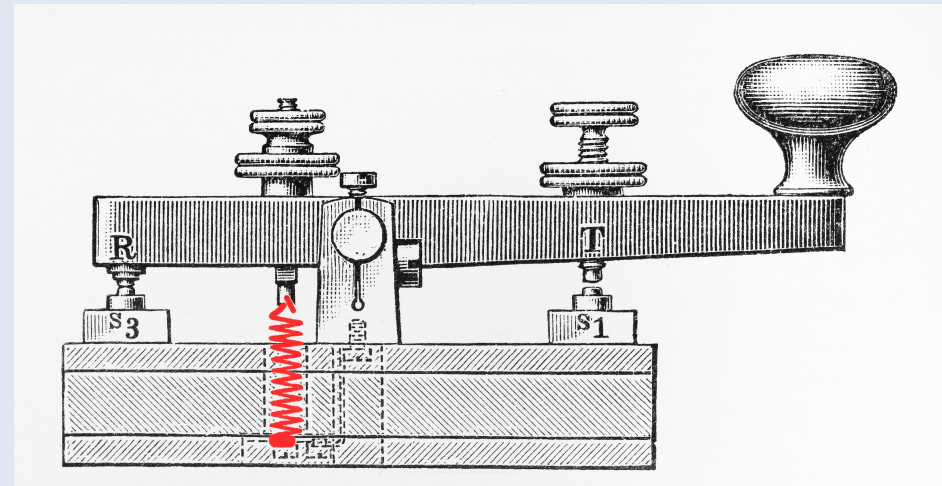
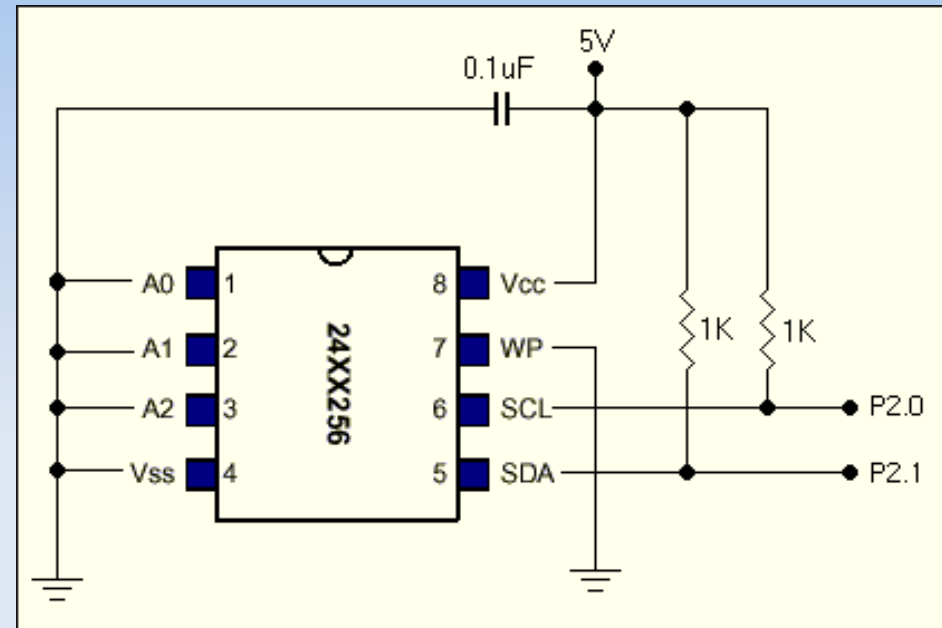
# Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS



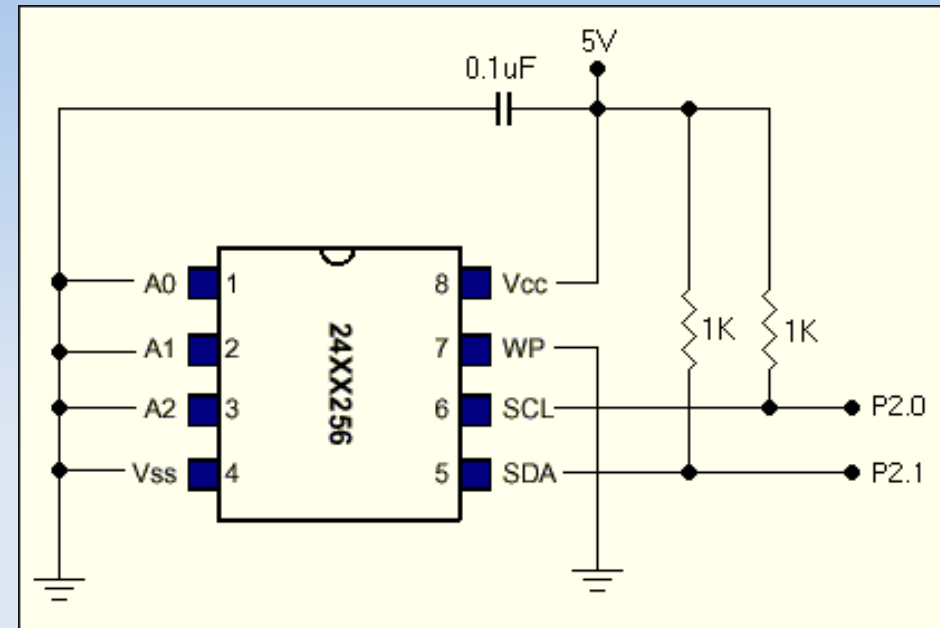
# Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
  - Pull-Ups



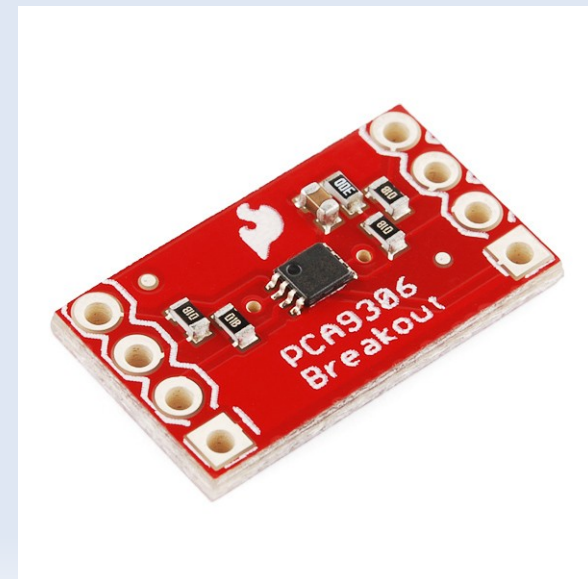
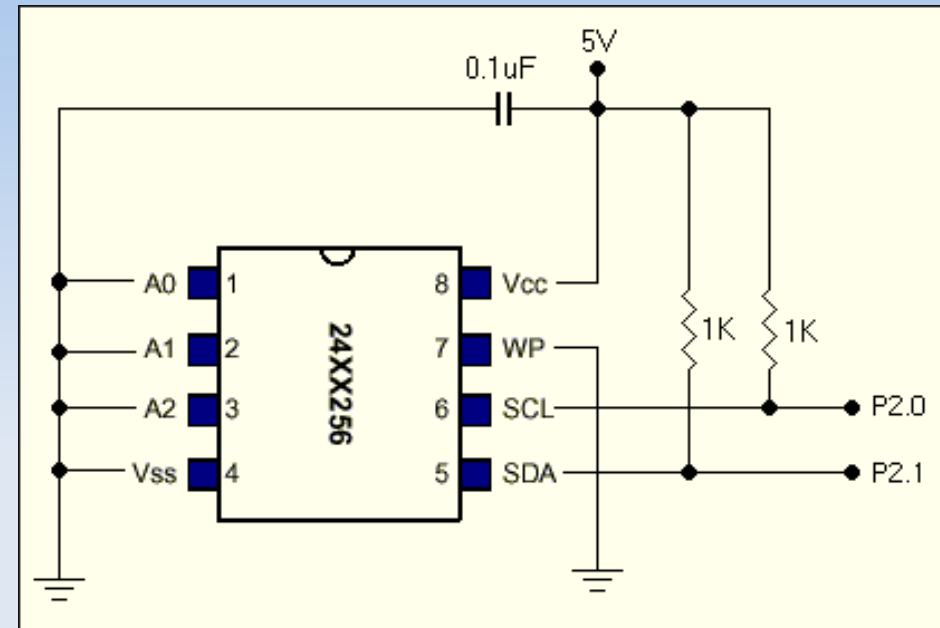
# Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
  - Pull-Ups
  - Address



# Interfacing

- Physical Connections
  - VCC, SCL, SDA, VSS
  - Pull-Ups
  - Address
  - Level Shifters



# Interfacing

- Physical Connections
- Drivers

# Interfacing

- Physical Connections
- Drivers
  - Bootloaders

# Interfacing

- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel

# Interfacing

- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel

```
danders@lap-dev: ~/Development/linux-3.5
File Edit View Search Terminal Help
.config - Linux/arm 3.5.0 Kernel Configuration

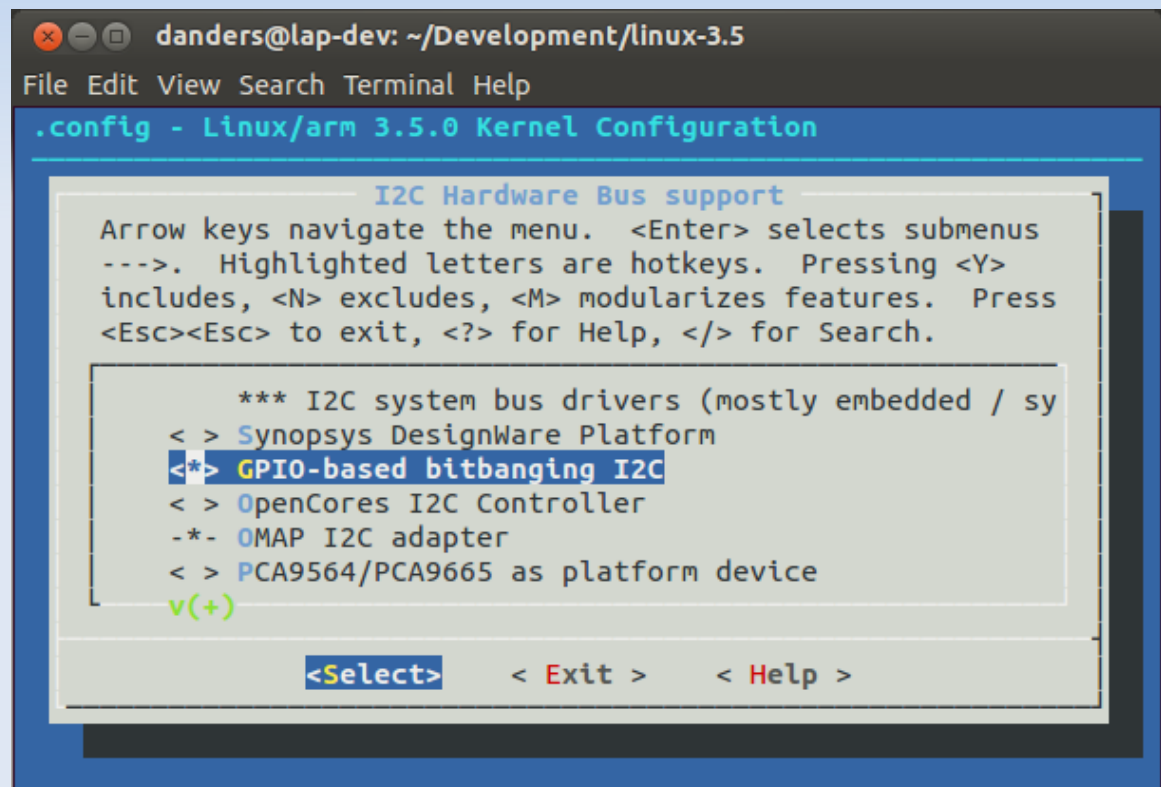
Device Drivers
Arrow keys navigate the menu. <Enter> selects submenus --->.
Highlighted letters are hotkeys. Pressing <Y> includes, <N>
excludes, <M> modularizes features. Press <Esc><Esc> to exit,
<?> for Help, </> for Search. Legend: [*] built-in [ ]

^(-)
Input device support --->
Character devices --->
[*] I2C support --->
[*] SPI support --->
< > HSI support --->
v(+)

<Select> < Exit > < Help >
```

# Interfacing

- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel
  - GPIO Bit-Bang



The screenshot shows a terminal window with the title bar "danders@lap-dev: ~/Development/linux-3.5". The terminal displays the "Linux/arm 3.5.0 Kernel Configuration" menu. The "I2C Hardware Bus support" section is expanded, showing a list of drivers. The "GPIO-based bitbanging I2C" option is highlighted with a blue background and white text. The list includes: "Synopsys DesignWare Platform", "GPIO-based bitbanging I2C", "OpenCores I2C Controller", "OMAP I2C adapter", and "PCA9564/PCA9665 as platform device". The "v(+)" symbol is visible at the bottom left of the list. At the bottom of the menu, there are three buttons: "<Select>", "< Exit >", and "< Help >".

```
danders@lap-dev: ~/Development/linux-3.5
File Edit View Search Terminal Help
.config - Linux/arm 3.5.0 Kernel Configuration

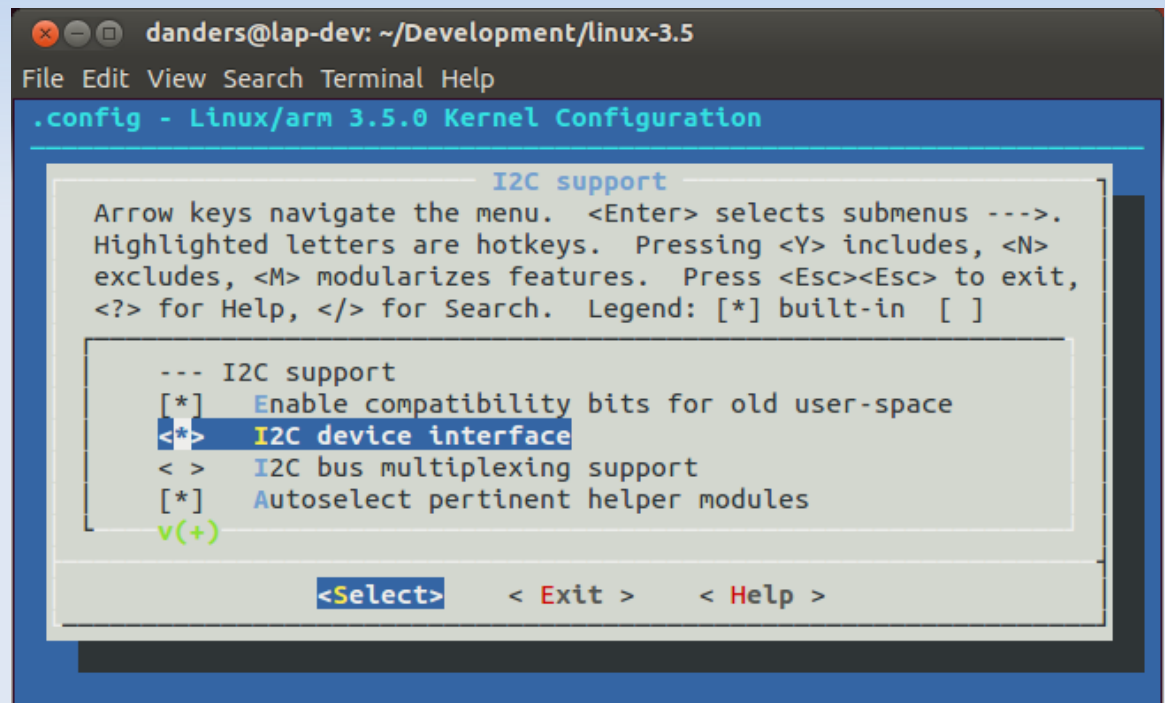
I2C Hardware Bus support
Arrow keys navigate the menu. <Enter> selects submenus
--->. Highlighted letters are hotkeys. Pressing <Y>
includes, <N> excludes, <M> modularizes features. Press
<Esc><Esc> to exit, <?> for Help, </> for Search.

*** I2C system bus drivers (mostly embedded / sy
< > Synopsys DesignWare Platform
<*> GPIO-based bitbanging I2C
< > OpenCores I2C Controller
-* OMAP I2C adapter
< > PCA9564/PCA9665 as platform device
v(+)

<Select> < Exit > < Help >
```

# Interfacing

- Physical Connections
- Drivers
  - Bootloaders
  - Linux Kernel
  - GPIO Bit-Bang
  - I2C CharDev



The screenshot shows a terminal window titled "danders@lap-dev: ~/Development/linux-3.5". The terminal displays the ".config - Linux/arm 3.5.0 Kernel Configuration" menu. The "I2C support" submenu is open, showing the following options:

- I2C support
- [\*] Enable compatibility bits for old user-space
- <\*> I2C device interface (highlighted)
- < > I2C bus multiplexing support
- [\*] Autoselect pertinent helper modules

At the bottom of the menu, there are three buttons: "<Select>", "< Exit >", and "< Help >".







# Interfacing

- Physical Connections
- Drivers
- I2C Tools
  - i2cdetect
  - i2cdump
  - i2cget
  - i2cset

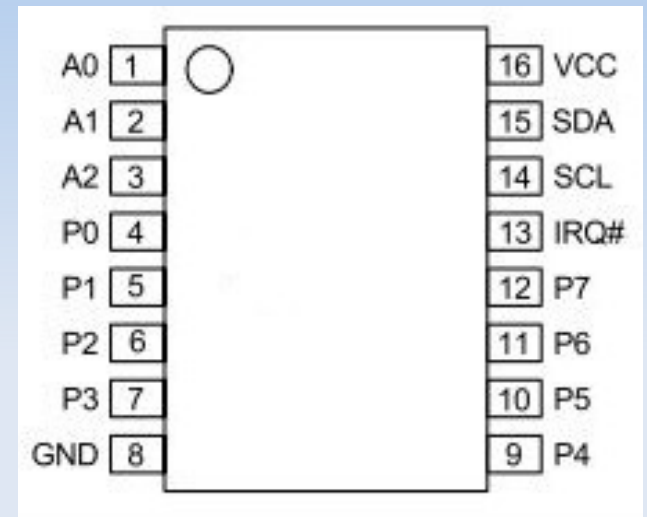
[illegible]

# Board Bringup

- I2C GPIO Expanders

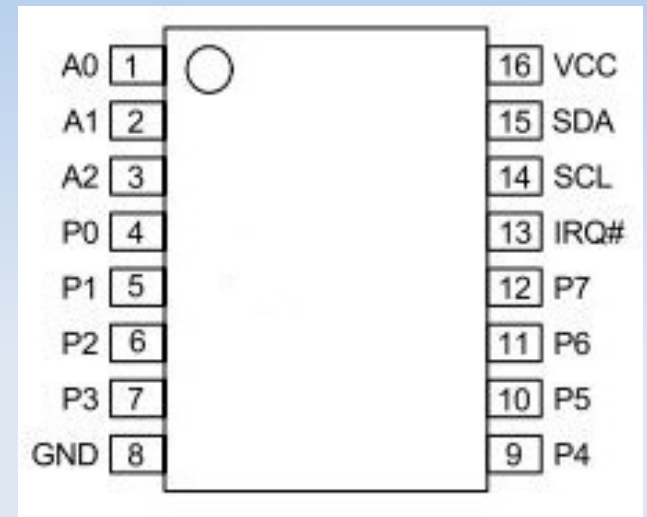
# Board Bringup

- I2C GPIO Expanders
  - Devices



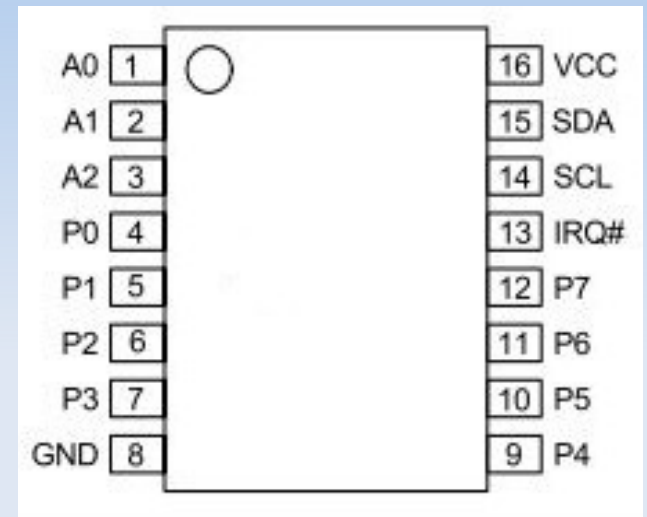
# Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output



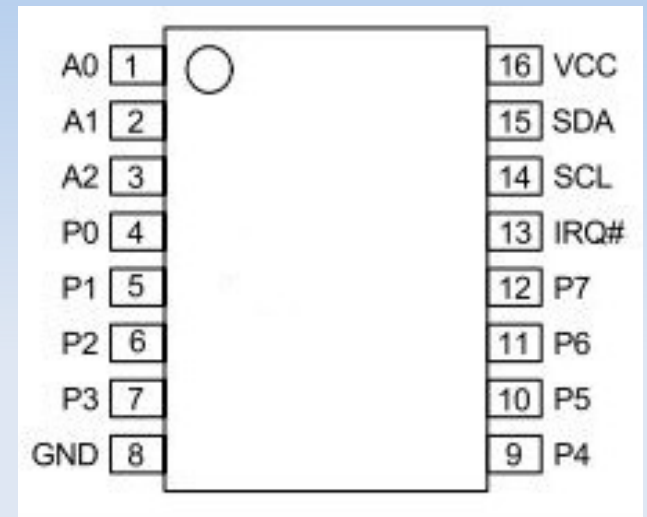
# Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output
    - IRQ for input events



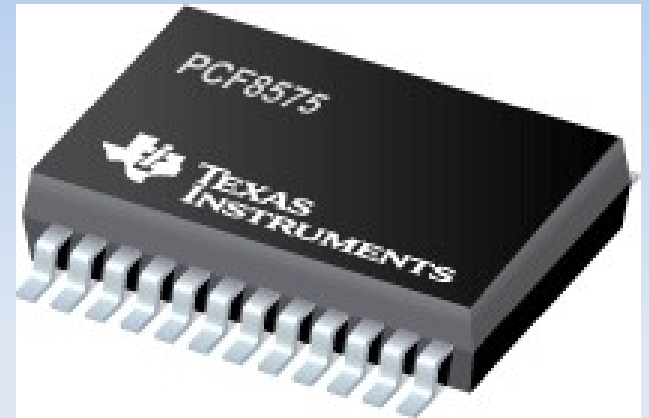
# Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output
    - IRQ for input events
    - Voltage range support



# Board Bringup

- I2C GPIO Expanders
  - Devices
    - 4 to 24 Inputs or Output
    - IRQ for input events
    - Voltage range support
    - Generic PCF857X



# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit

# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host

# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host
    - Different Voltage Levels

# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host
    - Different Voltage Levels
    - New GPIOs are Transparent

# Board Bringup

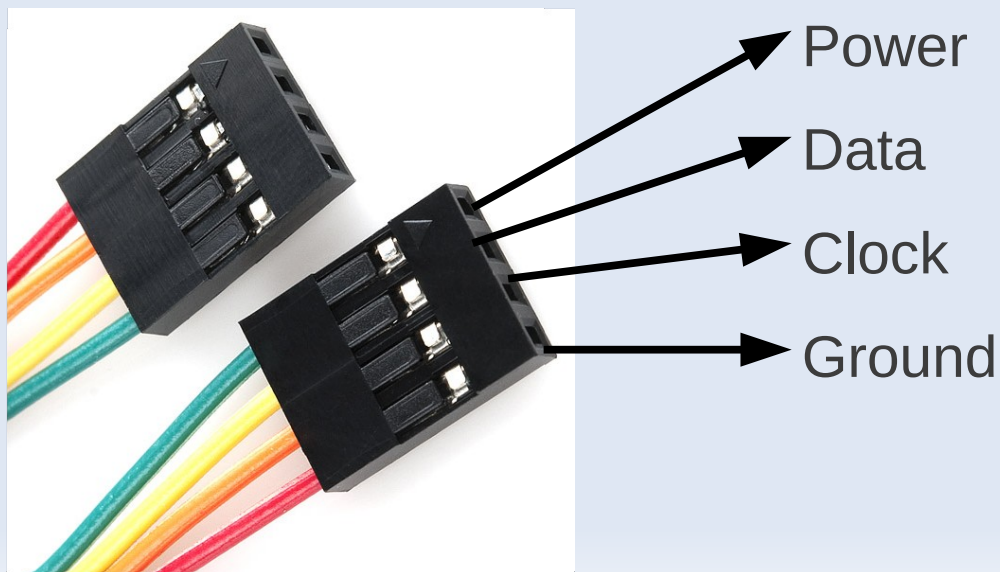
- I2C GPIO Expanders
  - Devices
  - Retro-fit
    - Only needs 2 GPIOS from Host
    - Different Voltage Levels
    - New GPIOs are Transparent
    - Inputs used for versioning

# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging

# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection



# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection
    - Provide Buttons for Test Modes



# Board Bringup

- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection
    - Provide Buttons for Test Modes
    - Provide LEDS for Low Level Feedback



# Board Bringup

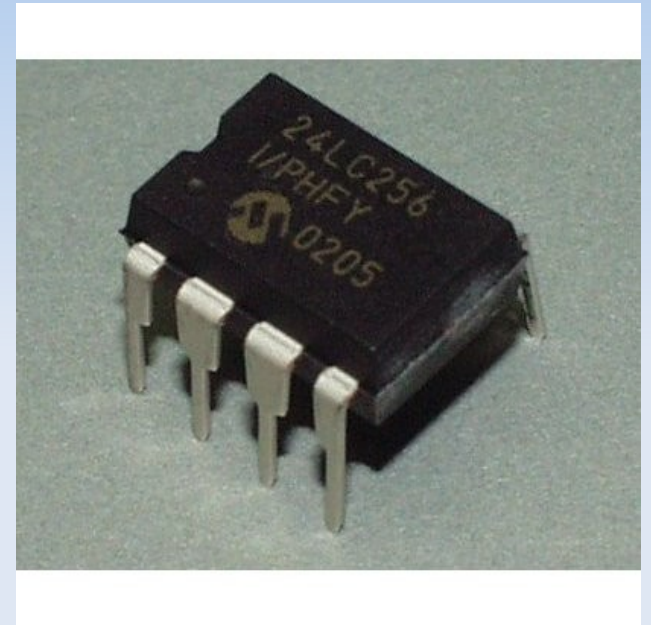
- I2C GPIO Expanders
  - Devices
  - Retro-fit
  - Debugging
    - Four Wire Connection
    - Provide Buttons for Test Modes
    - Provide LEDS for Low Level Feedback
    - Easily Removed when Done

# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS

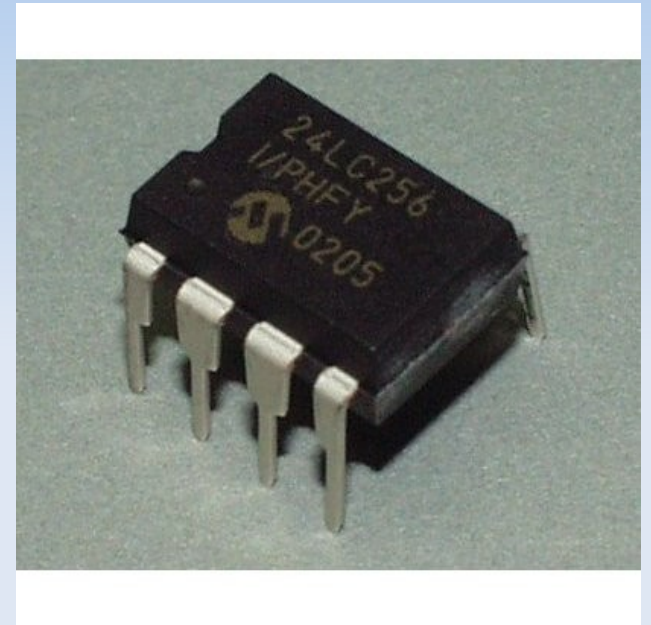
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices



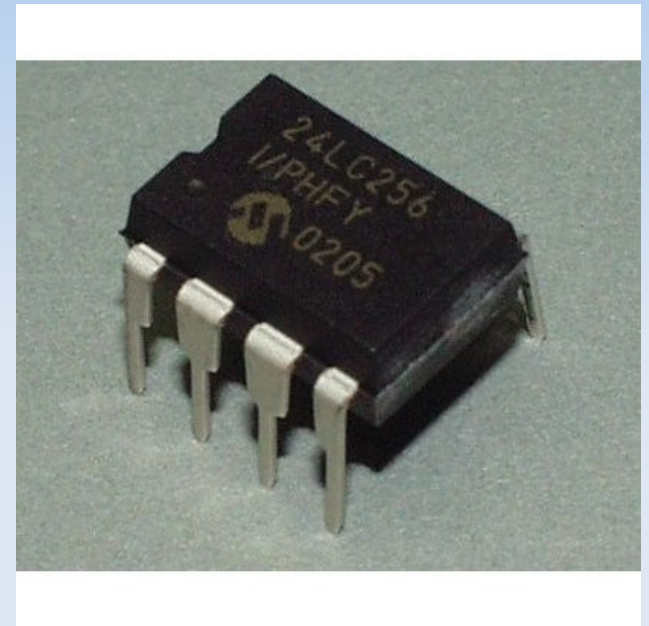
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Average 256 Bytes



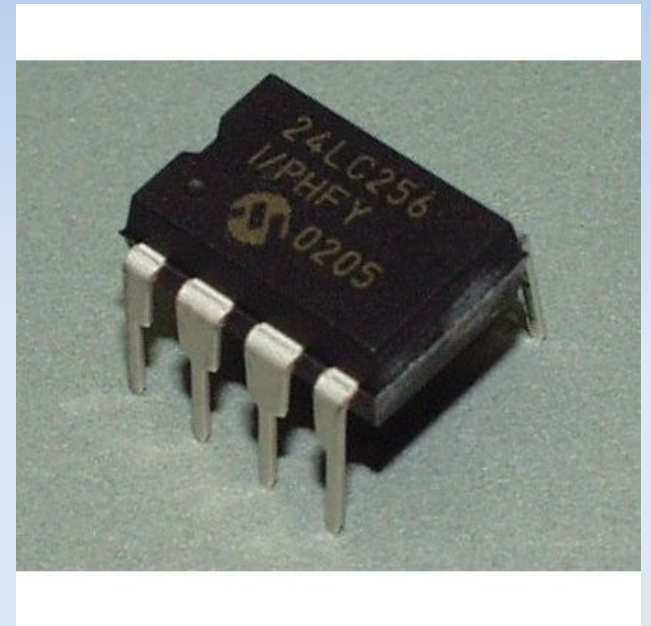
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Average 256 Bytes
    - Can be Write Protected



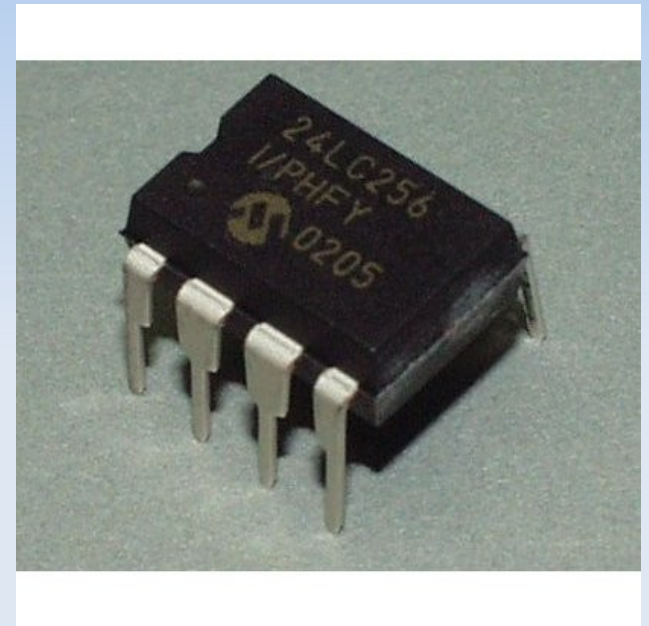
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Average 256 Bytes
    - Can be Write Protected
    - Low Cost



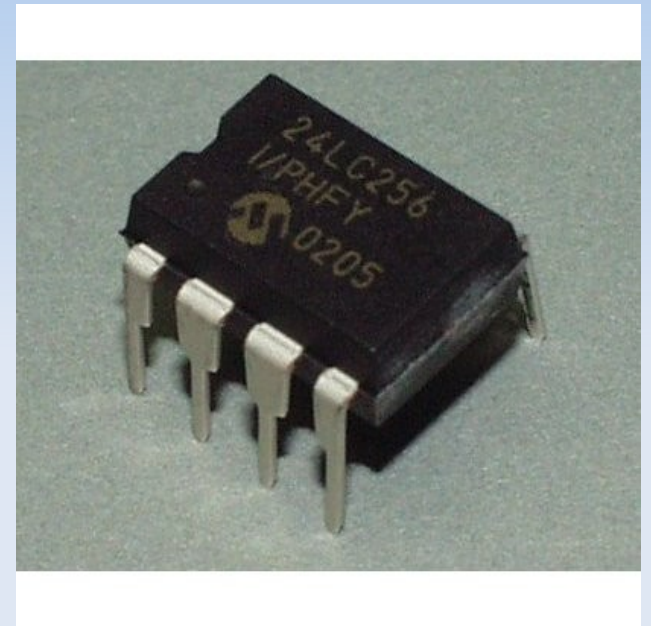
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
    - Average 256 Bytes
    - Can be Write Protected
    - Low Cost
    - Multiples per System



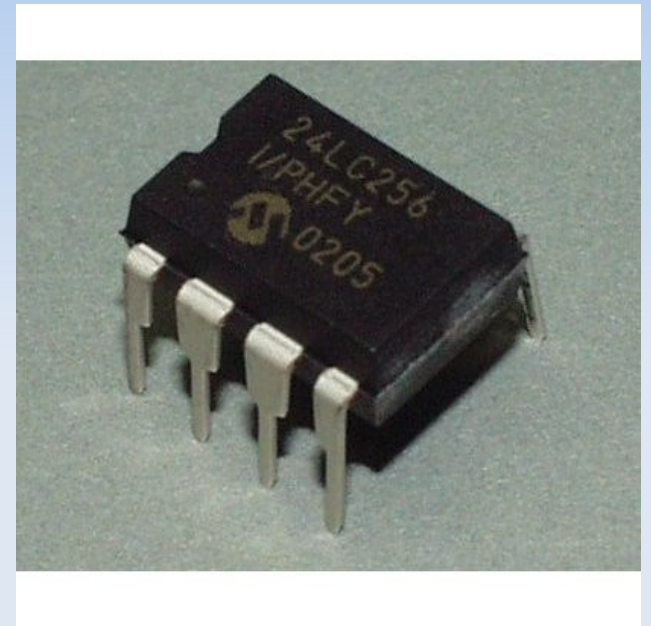
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning



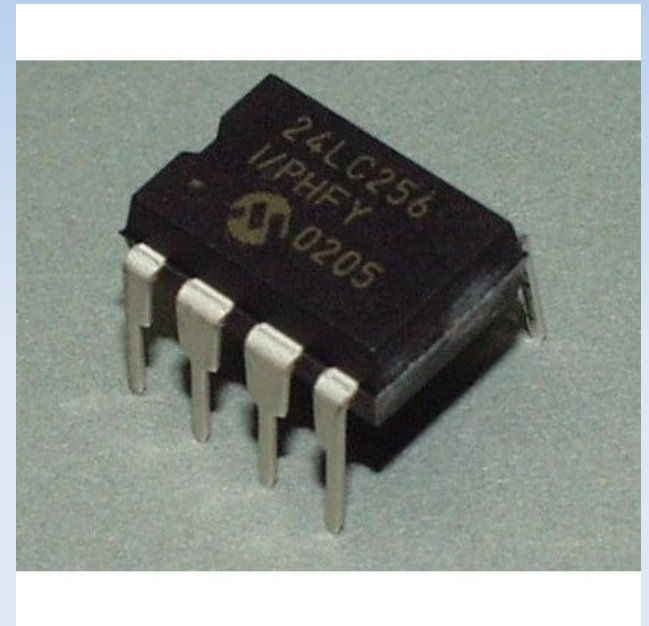
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
    - EDID



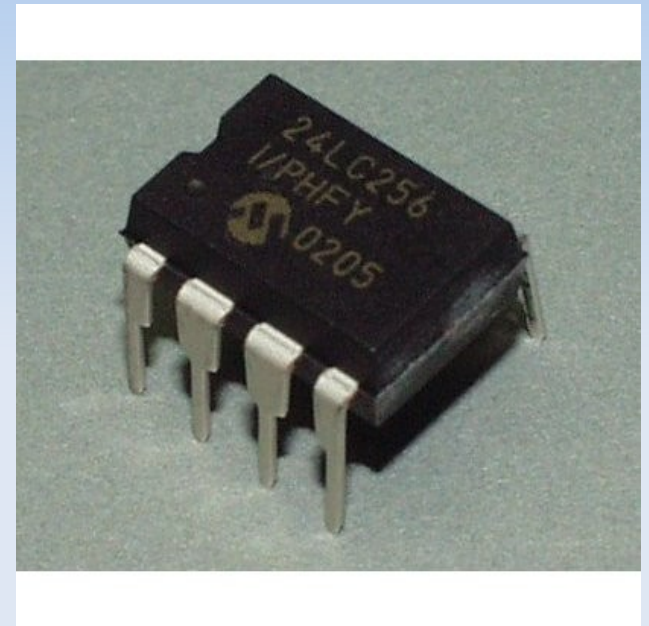
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
    - EDID
    - Part/Board Identifications



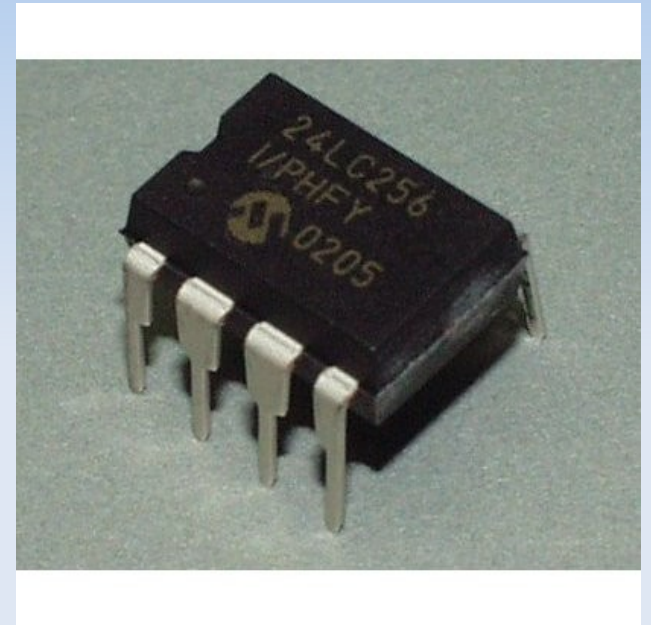
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
    - EDID
    - Part/Board Identifications
    - BeagleBone Capes



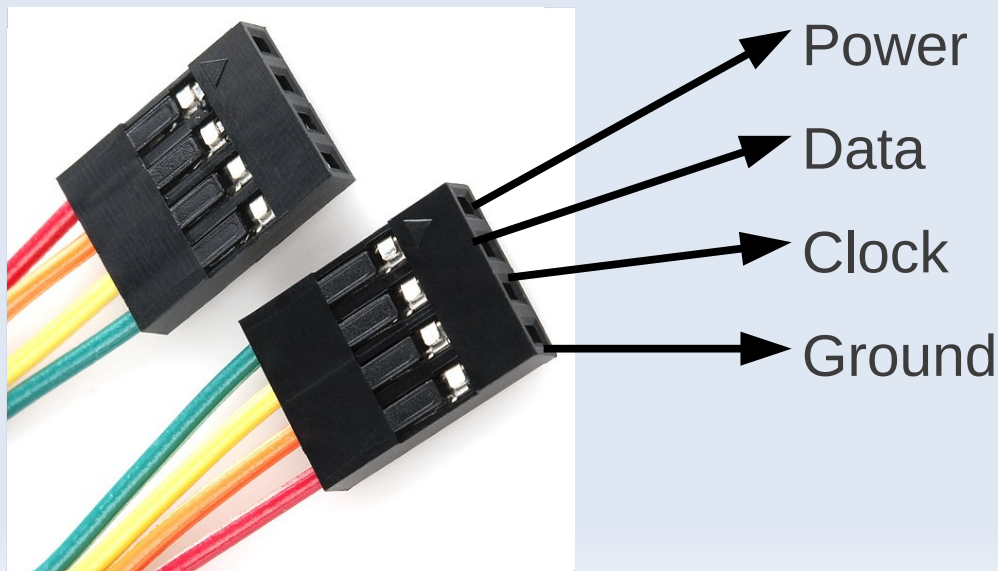
# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging



# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
- Four Wire Connection



# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data

# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data
    - Collect Board Interaction Data

# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data
    - Collect Board Interaction Data
    - Configure Test/Boot Modes

# Board Bringup

- I2C GPIO Expanders
- I2C EEPROMS
  - Devices
  - Versioning
  - Debugging
    - Four Wire Connection
    - Store Testing Cycle Data
    - Collect Board Interaction Data
    - Configure Test/Boot Modes
    - Easily Removed when Done

# Conclusion

- Communication Principles

# Conclusion

- Communication Principles
- Drivers and Software Tools

# Conclusion

- Communication Principles
- Drivers and Software Tools
- Board Bringup Use Cases

# Conclusion

Questions?